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VOL. XXIV.

1892-93.

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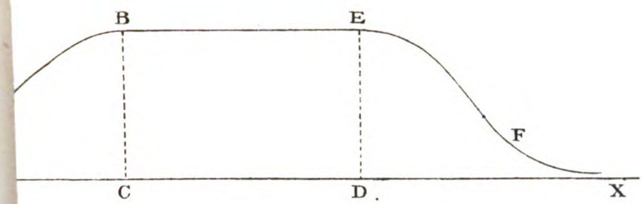

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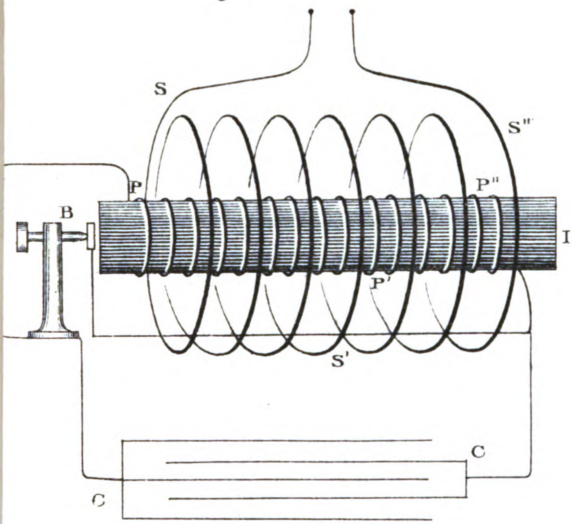

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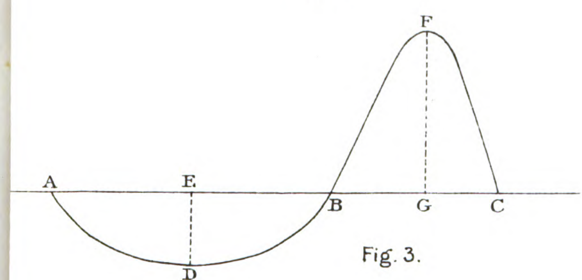

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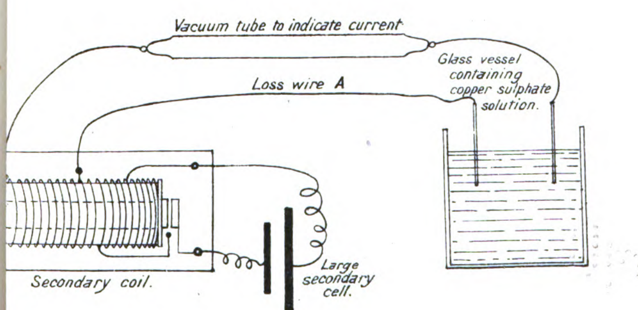

Fig. 4.

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NINETIETH SESSION.

I. — *Some Recent Experiments with a Ruhmkorff Coil.* By MAGNUS MACLEAN, M.A., F.R.S.E.

[Read before the Society, 30th November, 1892.]

PLATE I.

BEFORE bringing under your notice the results of the experiments performed with the Ruhmkorff coil, I may be permitted to state very briefly the elements of the subject of "The induction of electric currents." Suppose you have a conducting circuit in which there is a current of constant strength, then the only three electrical magnitudes to be considered are the current strength, the electrical resistance, and the impressed electro-motive force. The relation between these three is known as Ohm's law—namely, that the current strength is equal to the quotient obtained by dividing the impressed electro-motive force by the electrical resistance. If, however, the conducting circuit be subjected to a variable electro-motive force, the current is not obtained by the same simple relation. Another quality of the circuit has to be taken into account. This quality is called the self-induction of the circuit, or, shortly, inductance. The inductance of a circuit is a quality, in virtue of which, when a constant impressed electro-motive force is applied to it, the current does not all at once attain to its maximum value. It takes a certain time to do so. Similarly, after the current has attained its maximum and normal strength, if the electro-motive force be suddenly removed, the current does not instantly become zero.

In Fig. 1 (Plate I.) this is diagrammatically represented. Time is measured along the line OX, and current strengths are measured along OY. The line OA represents the maximum current, OC the time at which it practically attains that maximum (as represented by the curve OB), OD the time at which the electro-motive force was removed, and the curve EF represents the successive magnitudes of the current at successive intervals after the circuit was broken or the electro-motive force was removed.

The expression which gives the current strength c, at any time after the circuit is made, is readily found to be $c = C\left(1 - \epsilon^{-\frac{tR}{L}}\right)$, where C is the maximum current, R the ohmic resistance, and L the inductance. Analogues, if not pressed too far, greatly help the understanding of such quantities or qualities as that of inductance. Thus, inductance of electric circuits may be held to be analogous to mass in linear translation, or to moment of inertia in rotational motion. A finite force cannot in an indefinitely small time generate a finite velocity in a body on account of its inertia, and, similarly, a finite electro-motive force cannot generate in an indefinitely short time a finite current in a conducting circuit on account of its inductance. The other dynamical analogy will perhaps help us better. To start from rest, or to get up the speed of, a fly-wheel requires a couple which may be looked upon as made up of two factors; part of the couple is necessary to maintain the angular velocity of the wheel against the force of friction at its bearings, and another part to increase the angular velocity against the force of inertia, or, a part to cause rotation. Similarly the electro-motive force may be looked upon as made up of two parts also—one part to overcome the frictional resistance of the wire, and the other to increase the current strength in the wire. The one part is associated with an irreversible transformation of the electric energy into heat, and the other part is associated with the absorption of energy in the form of a magnetic field.

We must not, however, push the analogy too far, for the moment of inertia of the fly-wheel is constant, whereas the inductance of a circuit depends upon various factors. It depends :—

1. On the geometrical form of the circuit.
2. On the magnetic permeability of the conducting material forming the circuit.

3. On the magnetic permeability of the region which surrounds the conducting circuit.

4. On the strength of the current in the circuit when the surrounding medium is magnetic, like iron.

It is not my intention to enter into details regarding the values of the inductance of a circuit under different conditions, but simply to draw attention to the fact that when a current is increasing in strength or decreasing in strength in any conducting circuit, a magnetic field is started into existence round the circuit. The direction of the lines of induction round the circuit have the relation between the thrust and the twist of a cork-screw. Or, looking on a part of the circuit which we may suppose to be in the form of a curve, if the direction of the current be with the hands of a watch, then a north magnetic pole would be urged from the face to the back of the watch.

Suppose, now, that contiguous to this circuit, which may be called the primary circuit, there is another with no source of electro-motive force in it; this second circuit may be called the secondary. When a change of current takes place in the primary, there is a change of magnetic induction taking place in the secondary; and as long as this change of magnetic induction lasts, there is a current in the secondary. The direction of the current in the secondary coil is inverse when the current is *beginning* or *increasing* in the primary; and it is direct when the current is *stopping* or *decreasing* in strength in the primary. Lenz, in 1834, gave a statement by which the direction of the current in the secondary can in each case be found. It is known as Lenz's law, and is stated thus:—"In all cases of electro-magnetic induction the induced currents have such a direction that their reaction tends to stop the motion which produces them."

These theoretical conclusions are practically applicable to the induction coil, an apparatus invented by Mason, greatly improved by Ruhmkorff, and now generally called the Ruhmkorff coil. The apparatus is so well known that I need only refer to Fig. 2, which sufficiently explains the details of an ordinary Ruhmkorff coil. I is the iron core; PP′P″ the primary coil; SS′S″ the secondary coil; CC a condenser connected across B, which is the automatic electro-magnetic contact breaker; A the battery; and K a reversing key, by means of which the current can be sent through the primary coil in one or the other direction. The function of

the condenser is, I believe, but imperfectly understood by some, and many text-books, even those most commonly recommended to students, explain it rather crudely. The following, taken from one of the most widely-read elementary books in the country, though not incorrect, is certainly imperfect:—"The object of the condenser is, firstly, to make the break of circuit more sudden by preventing the spark of the 'extra current' from leaping across the interruptor; and, secondly, to store up the electricity of this self-induced extra current, in order that, when circuit is again made, the current shall attain its full strength gradually instead of suddenly, thereby causing the inductive action in the secondary circuit at 'make' to be comparatively feeble."

Lord Rayleigh very ably examined the nature of the condenser action in a paper in the *Philosophical Magazine* in 1870, Vol. XXXIX. I shall not enter into any of the mathematics of that paper, though quite elementary in its nature. My purpose will be served by quoting the last paragraph of it:—"The action of the condenser in the inductorium is very imperfectly explained in the text-books, and is, no doubt, in many cases rather complicated. From the reasoning of this paper, it appears that it is by no means a complete account of the matter to say that the advantage derived from the use of the condenser depends only on the increased suddenness with which the primary current is stopped. In a complete investigation (which I do not mean to enter on here) a distinction would probably have to be made, according as the secondary circuit when open allows the passage of a spark or not, or, as a third case, is completely closed. I would, however, remark that a good deal of misapprehension arises in this and similar cases from forgetting that a condenser is powerless to make away with electrical energy. Such energy may be disposed of in the form of a spark, or it may be converted into heat by the operation of electrical resistance; but the absorption in this way cannot take place instantaneously, requiring, as it does, a time comparable with the time constants of the circuits concerned. So far, indeed, is a condenser from itself absorbing electrical energy, that in many cases it actually prolongs the duration of motion; for an oscillatory current, in consequence of its smaller mean square, sustains itself twice as long against the damping action of resistance as a comparatively steady current of the same maximum value."

The action, then, seems to be that when the current is broken

the electricity goes on into the condenser, from which it immediately rebounds, retaining initially its full strength. The lines of force which were suddenly removed from the secondary circuit on breaking the primary circuit are inserted in the opposite direction to the same number; and hence there is an electro-motive force set up in the secondary, double what it would be if there was no condenser, or no rebound of the primary current. The condenser acts like a non-dissipative shunt circuit of negative self-induction, thus doing away with, or largely diminishing, the spark at the moment of "break" of the primary.

The effects of the electricity set in motion in the secondary, may be conveniently put under three heads:—(1) The effects which depend on the total quantity set in motion, such as the galvanometric and the electro-chemical effects; (2) the effects which depend on the average of the square of the strength of the current at every instant, such as the heating and the electro-dynamic effects; (3) those which depend on the maximum current, or on the rate of change of the current, such as the physiological, the telephonic, the luminous, the sparking, and the magnetic effects. As long as the secondary circuit is completely metallic, it can be definitely stated concerning the effects in the first class of effects that the total quantity of electricity set in motion in the secondary circuit by the "make" in the primary is equal to the total quantity set in motion in it by the "break" in the primary; but the durations are quite different.

Fig. 3 will help to illustrate this point. AB represents the time during which the inverse-make current lasts, and BC the time during which the direct-break current lasts, DE the maximum of the inverse current, and FG the maximum of the direct current. The area ADB, which represents the total quantity of the inverse-make current, is equal to the area BFC, which represents the total quantity of the direct-break current. That the quantity set in motion by the "break" is equal to the quantity set in motion by the "make" was experimentally proved by Faraday, and subsequent theory and experiments have corroborated the fact. If, however, there is a non-metallic gap in the circuit, whether of air at ordinary pressure, or at much reduced pressure, as in vacuum tubes, the effects for the most part fall under the third class. The "break" impulse causes a flow in one direction, and the "make" causes either no flow or a much less flow in the opposite direction; because the short,

intense impulse of the former breaks down the resistance, while the comparatively long and less intense impulse of the "make," either does not break down the resistance at all, or only does so to a much less degree, so that the effective resistance is much greater in one direction than in the other.

To obtain the average difference of quantity of electricity set in motion in one direction above that in the other, a copper electrolytic cell was put in circuit with a vacuum tube and the secondary coil of a small Ruhmkorff coil. The arrangement is shown diagrammatically in Fig. 4. The solution in the cell was copper sulphate of density 1·17, with one-half per cent. of commercial sulphuric acid added. The electrodes were No. 36 BWG copper wire, 0·012 centimetre in diameter, and they were immersed in the solution as little as possible, so as to give the best current-density for the deposit. To obtain the best result, the total immersed area of the cathode plate should be 50 square centimetres per ampere. The greater number of the experiments were performed by Mr. Alex. Galt, B.Sc., F.R.S.E., in the Physical Laboratory of the University. It was imperative that the small and very light electrodes should be manipulated with the greatest care. Before each experiment they were carefully cleaned, dried, and weighed, and at the end of the experiment they were detached singly from the connecting wires, plunged at once into a vessel of clean water to remove any adhering copper sulphate, and immediately placed in the folds of thick dry blotting paper, where they were thoroughly dried, then they were again weighed.

Table I. gives the results of seven of the experiments. The shortest time any of these experiments lasted was one hour and ten minutes, and the longest time four hours and five minutes.

TABLE I.

Date.	Time the experiment lasted in seconds.	Loss of one wire in milligrammes	Gain of other wire in milligrammes	Current in milliamperes calculated from the gain wire.	Remarks.
1892.					
June 6	7,200	0·24	0·3	0·127	The average current given by these seven experiments is one-sixth of a milliampere.
,, 7	4,200	0·0	0·23	0·1669	
,, 8	10,980	0·42	0·29	0·0828	
,, 10	9,660	0·1	0·3	0·0946	
,, 14	10,800	0·83	0·88	0·2484	
,, 15	13,500	0·89	1·04	0·2224	
,, 16	14,700	0·58	0·88	0·1819	

The average current showed by all these experiments is one-sixth of a milliampere. It is noticeable that the gain is in six of the seven experiments greater than the loss—the one exception being that of June 8th. On looking up the laboratory note-book, no remark is found regarding this experiment to in any way explain why in this respect it differs from all the other experiments.

An electrolytic cell with copper electrodes was now inserted in the primary, and Table II. gives the results of three experiments. The current in the secondary coil, calculated from the gain wire, was found to be slightly less than a sixth of a milliampere, and the average current in the primary, calculated from the gain plate, a little less than an ampere. The mean ratio between the two currents was 6,000.

TABLE II.

SECONDARY CIRCUIT.

Date.	Time experiment lasted in seconds.	Gain of plate in Primary circuit in grammes.	Current in Primary calculated from gain plate in milliamperes.	Loss of one wire in milligrammes.	Gain of other wire in milligrammes.	Current calculated from gain wire.	Current in Primary ÷ current in secondary.	Remarks.
1892. July 4	10,080	3·0229	914·3	0.33	0·55	0·166	5496	Taking the average of these results, it is found that the current in the primary is 6,000 times that in the secondary, which is a little less than that found in Table I.—namely, one-sixth of a milliampere.
„ 5	10,800	3·10465	876·4	0·62	0·43	0·121	7220	
„ 6	10,800	2·08885	589·0	0·58	0·40	0·113	5222	

A long thermometer tube, full of solution of copper sulphate, was now inserted in the secondary circuit instead of the vacuum tube. In this case there was no air gap in the secondary circuit. The whole circuit was completed by metal and copper sulphate solution. The results obtained are inconclusive, as sometimes both electrodes showed a slight loss, and sometimes they indicated neither gain nor loss. Some experiments were also tried with an air gap instead of a vacuum tube, the results obtained being similar to those obtained with the vacuum tube. A few experiments were also tried with nothing in the secondary circuit but the secondary

coil and the electrolytic cell. In every case both the electrodes showed loss.

It would be interesting to try these experiments, commencing with the largest air gap that the secondary coil could spark across, and gradually diminishing the air gap till there is metallic contact. A beginning has been made in this direction, but no definite results have as yet been obtained.

II.—*Reformed Public Houses: Notes upon the Scandinavian Licensing Systems and the Bishop of Chester's Recent Proposals.* By JOHN MANN, JUN., M.A., C.A. *(A Communication from the Economic Science Section.)*

[Read before the Society, 16th November, 1892.]

I.

THE problems presented by the liquor traffic are so vast, and bristle with so many difficulties, that in the limited time at my disposal, I can only very briefly touch upon some leading principles, such as Prohibition, High License, and Local Option, while I shall treat more in detail some other principles which have acquired a special interest at this time.

Many people class alcohol with arsenic, treat it as a poison, and cry out for the total prohibition of its sale. Various prohibitory experiments in the United States and Canada are in evidence, but they have given rise to most conflicting conclusions. One point is perfectly clear—*in no town or city* has the sale of liquor been stamped out: indeed, the prohibitory law is often violated. Even in Maine, for thirty years the stronghold of Prohibition, this is acknowledged.* The temperance reformers in America, by means of organisations more able and powerful even than our own, have succeeded from time to time in forcing some of the great cities to follow the example of Maine; but, after trial of Permissive and Local Option Acts of almost every kind, the experiment of Prohibition has been abandoned in these cities. It is found that illicit drinking becomes rampant, supervision breaks down, witnesses will not speak out, convictions cannot be obtained, the law is openly defied, and, at last, repealed as unworkable. Recent official reports confirm this, and speak of "*the*

* The Governor of Maine, in his annual address for 1891, said—"It cannot be denied that the law for the suppression of the liquor traffic is often violated, and that officials charged with its enforcement are frequently derelict in duty. But it is undoubtedly true that this condition of affairs is mostly confined to our cities and larger villages."

absolute impracticability" of working out the prohibitory theory.* Canada is in a transition stage. While the Scott prohibitory law has to some extent succeeded in sparsely populated districts, I think it has admittedly failed in the large towns. The Government is now investigating the working of that law, and the result is awaited with interest.

We are told that in America, prohibition has become merely a party cry, and that the prohibitory laws contain no proper provisions for their enforcement. Therefore it is argued that the failure of prohibition abroad is no proof that it would not succeed here, because it would be properly enforced here. I firmly believe, on the other hand, that the feeling of our own country at present is against total prohibition—against that entire extinction, abolition, and extermination which some people demand—and that any such law, though looking well in the statute book, would become a dead letter. To be effective, any measure of social reform must have the support of public opinion. My conclusion, therefore, is that prohibition is impracticable, or at least premature, in our great cities.

In America, public feeling is now strongly supporting "high license"—that is to say, the exaction of a payment for each public-house of from £50 to £200 or more; in many cases coupled with

* See Foreign Office Reports on Liquor Traffic Legislation in the United States (No. 78, 1888) :—"Unfortunately, the proper and just enforcement of this system (prohibition) is surrounded with so many difficulties that it is in the eyes of many who have earnestly and impartially studied this question a simple impossibility. Total abstinence cannot be legislated into a nation." (Page 33.) Also Report No. 154 (1890):—"Wherever prohibition does exist, the sale of liquor continues all the same, and conviction by the magistrate of the offender against the law is almost always impossible for want of evidence." (Page 10.) "The popular vote has been taken since 1887 in five States on the question of adopting an amendment to the State Constitution by which, if carried, prohibition would have been established in the State. In each case the voters have declared themselves by a large majority against prohibition. . . . In Rhode Island in 1886 prohibition was carried by the necessary majority. In 1889 prohibition, which had thus become a law of the State Constitution, was defeated by the necessary majority. . . . The theory of prohibition may be worthy of consideration and praise, but the absolute impracticability of the working of such a system in most places where it has been tried has led a large number of those who earnestly desire to promote temperance to consider whether the object they have in view will not be better advanced by a change to a system of legislation which, although not so perfect in theory, can be practically worked." (Page 36.)

substantial security for the proper conduct of the business. This scheme is well worthy of more detailed consideration than I can give it now; but I may state that, where statistics are obtainable, they all show that "high license" has reduced the number of public-houses—generally by closing those of the lowest type—and has also diminished drunkenness. It places the trade in the hands of wealthy, and, it may be urged, more responsible men. But on this account it is liable to abuse. Private monopolies may be created; and with every increase in the license duty and in the prices of drink, the temptations to illicit traffic and adulteration increase.

In our own country efforts are mainly directed to restriction of the hours of sale, and reduction of the number of licenses. The Local Option and Local Veto Bills are naturally expected to provide the machinery to effect either prohibition or reduction of licenses; but, so far as I am aware, no Bill lays down the method or plan to be followed by the licensing authority in reducing licenses where a district shall have declared in favour of reduction. The temperance party are not agreed upon the method to be followed in such cases. However, it is not within the scope of my paper to discuss local option any more than prohibition or high license; to my mind we must find an answer to some deep and searching preliminary questions before we deal with the mere restrictive policy of reduction of licenses.

While all good citizens and social reformers may agree with the advocates of temperance that our large cities present far too many opportunities for drinking, far too many temptations to excessive drinking, still they are not agreed that a simple reduction of licensed houses will proportionately reduce the consumption of drink, or much affect the amount of drunkenness and its attendant miseries. Statistical tables, Parliamentary Returns, Police Reports, Royal Commissions, have all dealt with the restrictions and their effect upon the immoderate use of stimulants. They bring to light anomalies difficult to explain; no general cause having yet been found to account for the variations. Strange as it may seem, no *direct* relation can be shown to exist between the number of licensed houses and the amount of intemperance.* Consumption of liquor and the arrests for drunkenness seem to rise and fall with the prosperity of trade, the rate of wages, and the amount

*Report of Select Committee of the House of Lords on Intemperance, 1879, pp. 32 to 38.

of leisure, rather than with the facilities for procuring drink. I cannot delay to elaborate this point, beyond simply emphasising my contention that mere reduction in licenses, mere restriction, will not effect all we want. I believe it will do much good, but it may also do much harm, by driving the evils deeper, and out of sight, while undoubtedly subsidising the remaining publicans at the expense of dispossessed licensees and of the ratepayers. The publicans themselves tell us this; the police tell us this; statesmen tell us this. Is the intemperance of our large towns to remain an unsolved problem? The temperance party have no suggestion to offer but the purely negative and destructive policy of haphazard reduction and restriction as a step towards total prohibition. What is to be done?

II.

Fortunately, we have before us in Norway and Sweden definite experiments in *restriction, but combined with other provisions of a constructive nature.* These experiments are well known to many of you, and are worthy of minute description; but I can only endeavour to make clear the leading features.* These are:—

(1) As the Scandinavians deem it impossible to stamp out the liquor traffic in towns, they seek to regulate and adjust it to meet *only the actual wants of the people.*

(2) The traffic is taken out of the hands of self-interested, and often unscrupulous persons, and is controlled by a company of citizens pledged to manage it in the interests of temperance and morality.

(3) The whole profit (after payment of expenses and interest on the capital required) is handed over to the community; and no individual, whether shareholder, manager, or servant, has any profit from the sale of liquor. In this way all incentive and temptation to extend the consumption unduly are abolished.

(4) In Sweden the surplus is applied to relief of local taxation; in Norway to various local benevolent objects and institutions supported by voluntary contributions.

(5) By monopolising the traffic, and suspending the principle of competition, order is enforced, prices are raised, and *direct*

*It is interesting to note that the subject was first discussed in Scotland, or indeed in Great Britain, by the late Mr. David Carnegie, of Stronvar, Lochearnhead, in a paper read before the Philosophical Society of Glasgow, on 2nd December, 1872, entitled "The Licensing Laws of Sweden, and some account of the great reduction of drunkenness in Gothenburg."

limitations placed upon the *use* of intoxicants, which again, indirectly, tend to prevent their *abuse.*

(6) Beyond periods of grace, no compensation is allowed to dispossessed license-holders.

To many the distinctive feature of these schemes may be new, but may, nevertheless, carry conviction at once, viz.: *first* render perfectly disinterested all those engaged in dealing out the spirits, as well as those controlling the traffic, *then* restrict the traffic to the legitimate demands of the people. Observe that the prohibitionists demand merely restriction; we have a new idea—the elimination of profit-making. In theory the sale is made for *use,* not *profit.*

Enormous profits have, however, been realised, and, as both Norway and Sweden were overburdened with taxation, these profits have been far from unwelcome. This explains to some extent how universally the Swedish towns have followed the example set by Gothenburg now nearly thirty years ago. In Gothenburg alone the surplus handed over to relieve taxation in 1889 amounted to £38,000, or 7s. 9d. per head of the population. The Norwegians deem it a blot on the Swedish system that the taxpayers have so direct an interest in the profits, and accordingly they apply the annual surplus "in grants to deserving charities, benevolent societies, philanthropic institutions, or other objects of public utility and benefit, which are dependent for their existence on the voluntary support of the public alone. Any charity or institution deriving aid, however small, from the local treasury or rates, is disqualified from participation in the grants."* The purity of motive in such circumstances can hardly be impugned, and therefore it is all the more interesting to note that the system has spread in Norway as rapidly as in Sweden. In practically every town in Norway with a licensing authority—51 in all—a society has been formed to monopolise the licenses. Since the system was introduced into Bergen, in Norway, thirteen years ago, the net profit has amounted to £79,000, or an average of £6,000 per annum, being over 2s. 8d. per head of the population. This sum has been contributed to labourers' dwellings, labourers' waiting and reading rooms, coffee houses, clubs, lecture rooms, theatres, and a host of other beneficent objects.

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* "Local Option in Norway." By Thomas M. Wilson, C.E., Bergen; London: Cassell & Co. 1891.

So much controversy has arisen over the statistical results of the operations of the Scandinavian societies, that I hesitate to place results before you. Morality cannot be expressed in figures, and I have hardly time to explain the varying conditions of trade, police stringency, &c., which explain fluctuations in the statistics. Premising that I do not lay much stress upon the figures, I submit the following table, compiled from (*a*) the Gothenburg Company's Reports for the past 27 years; (*b*) a pamphlet issued in 1890 by Herr Rubenson,* the Chief of the Stockholm Police.

TABLE I.—DRINK STATISTICS—SWEDEN.
GOTHENBURG AND STOCKHOLM.

YEARS.	GOTHENBURG.		Gallons of Spirits per head of Population.		
	Average Annual Arrests for Drunkenness per 1,000 of Population.	Inhabitants to each License.	Sold by the Companies.		Consumed in Sweden.
			GOTHENBURG.	STOCKHOLM.	
1855,.......	138	—			
1856,.......	79	—	No	Statistics.	
1865,.......	45	—			
1866-72,...	27	—			2·07
1873-74,...	35	—			—
1875-77,...	40	1,063	6·06	—	2·66
1878-82,...	33	1,059	4·56	5·27	1·95
1883-87,...	30	1,161	3·90	3·99	1·71
1888-90,...	34	1,349	3·58	3·43	—
1891,.......	44	1,488	3·25	—	1·50

Taking the Gothenburg figures, two broad results are clear:—(1) The convictions for drunkenness per 1,000 of the population vary considerably. They show a marked decrease upon the suspension of free trade in drink in 1855, and a further decrease upon

* Le Système Suédois réglant le Commerce des Boissons Fortes, par Semmy Rubenson, Chef de la Police de Stockholm. Stockholm, 1890.

the commencement of the company's control in 1864-65. With improving trade and wages, a steady increase in drunkenness took place until 1877, the detailed figures showing a temporary check in 1875-76, when the company was first entrusted with the full control of the spirit sales. With depressed trade, and, perhaps, through the company having raised its prices in 1880 and 1884 (in all 33 per cent.), the convictions for drunkenness were maintained at a low level until 1888. With reviving trade, they have since steadily risen, until in 1891, perhaps Sweden's most prosperous year, the number is higher than for any year since the company commenced its operations. (2) The second result shown is that the sales of spirits, both by the Gothenburg and Stockholm companies, have steadily diminished through good times and bad times, and at about double the rate of decrease of the general consumption in Sweden.

The prohibitionists attribute the original diminution of drunkenness to reduction of licenses and to restrictions of supply, and to these causes alone; while they explain the increase in convictions from 1866 to 1877 by alleging that the country was becoming reconciled to the traffic, owing to the enormous profits realised. They have again quite recently attributed the increase in convictions in 1883-90 to the same cause, ignoring the diminution in 1878-82, which clearly points to variations in trade and wages as most important factors. The original diminution was intensified by a succession of bad harvests, and the recent increase by a period of good trade. The insinuation of indifference to the evils of the traffic has been indignantly repelled by the honorary directors and officials of the company, by many leading inhabitants, and by the Swedish temperance party itself.* It is quite possible, however, that the destination of the profits may have an unconscious influence upon the community.

The steady reduction in the company's sales points to other explanations of the recent increase in convictions, such as

* "Many friends of temperance feared that the large revenue derived from the traffic would induce the Commune to make a profit out of vice, . . . hence they were anxious to do away with this revenue: . . . they accused the Companies of being actuated by mercenary motives. . . . The General Swedish Temperance Convention at Jönköping, August 1st, 1880, expressed itself unanimously against this view."—"The Gothenburg System," by Dr. Wieselgren. Gothenburg: 1886.

increased police stringency, increased sales of spirits in large quantities by the distillers, and of malt liquors by the ale-houses, neither of these sources of supply being in any way controlled by the company.* Taken along with the great increase in the company's prices of spirits, and the supervision exercised, it is a fair assumption that illicit sales and shebeening have become profitable, and that more private drinking of spirits takes place. These are fruitful sources of drunkenness.

We have direct corroboration of this in certain statistics kept by the police at Gothenburg, showing the places wherein drunkards were last supplied with liquor. These indicate that the cases of drunkenness traced to the company's shops have decreased from 40 per cent. of the total cases in 1875-76 to 22 per cent. in 1888-89; the remaining cases were either not traced, or were traced to private houses and beershops not owned by the company. The drunkards, when unable to get either beer or spirits in the company's shops, went to beershops, shebeens, or, perhaps, clubbed together and bought a wholesale quantity. This hardly shows that the company is responsible for increased drunkenness, unless, indeed, in so far as its policy has been tending towards prohibition.

It is worthy of note that the relatively greater consumption of spirits in the Swedish towns over the consumption for the whole country is undoubtedly due to the very small number of licensed houses in the rural districts there. When restrictive legislation was first introduced, these districts energetically applied the power of veto granted to all districts; but this has intensified the drinking in the towns, in none of which, as above stated, has prohibition been deemed either possible or advisable. In 1888, in the country districts in Sweden, there was one license to each 18,000 of population, while in Gothenburg there was one license to each 1,300, and in the other towns and villages one to each 800 or 900 persons. For the same reason, one-third of the drunkenness of Gothenburg and one-fourth of that of Bergen is said to be caused by the excesses of the country people, who can get little drink in their own districts, and accordingly crowd into town on market days and holidays, and, during their

* These surmises have since been confirmed by authoritative information from Scandinavia — the increase of arrests being due to great rigour in the application of a police bye-law. As the community progresses in the way of temperance reform, the ideal of good behaviour rises, and police regulations are progressively enforced.

temporary stay, absorb more and go to greater excesses than the average townsman.

I have also prepared the following tables from the Glasgow Police Reports for the past twenty years, and from the Inland Revenue Commissioners' Reports:—

TABLE II.—DRINK STATISTICS—GLASGOW.

Years.	Average Annual Arrests per 1,000 of Population.					Inhabitants to each License.	Average Rent of each Licensed House.
	For Total "Police Offences."	For "Drunk and Incapable."			For "Assaults and Disorderly Conduct."		
		Males.	Females.	Total.			
1876-80,	74	18	8	26	41	279	£97
1881-85,	76	17	8	25	43	296	104
1886-90,	77	18	9	27	42	317	101
1891,....	83	23	11	34	43	331	100

TABLE III.—DRINK STATISTICS—UNITED KINGDOM.

Years.	Quantities Consumed per head of Population.			
	Spirits. (Gallons.)	Foreign Wines. (Gallons.)	Beer. (Barrels.)	Tea. (Pounds.)
1852,..............	1·095	·231	·610	1·993
1862,..............	·821	·334	·661	2·694
1872,..............	1·126	·526	·884	4·005
1882,..............	1·047	·407	·768	4·685
1885-89,..........	·941	·372	·763	5·006
1890,..............	1·024	·398	·834	5·177
1891,..............	1·034	·390	·837	5·353

These figures speak for themselves, and may well make us pause and consider whether our religious, social, and temperance reform

work in Glasgow is really proceeding upon the best lines. The increase of insobriety amongst women is especially deplorable; I understand it is largely attributable to the facilities for procuring intoxicants quietly along with groceries. I am assured that in Glasgow there has been no increase in police stringency during the past twenty years to account for the increased arrests.*

As I have said, too much stress must not be placed upon any comparisons of these tables with those of Scandinavia, nor upon the results of each within itself. Not only do variations of habits, wages, education, and police stringency, affect the results, but important differences also exist in climate, in the conditions of labour, the standard of punishable drunkenness, and the prices of liquor.† The extent of counter attractions to the public-house, and all the social and religious influences brought to bear upon the people, are most important elements.

I may add, in passing, that in Glasgow the net profit upon the retailing of the spirituous drink sold is enormous. From careful calculations which I have made, I believe that the net profit is considerably over £300,000 per annum, after payment of licenses, rent, taxes, wages, &c.

Two years ago, a "Report on the Working of the Gothenburg System since 1876" was specially drawn up for our Foreign Office. This Report states—"There can be little doubt that the influence of the new system must have been beneficial from the very commencement, but this influence was, during the first ten years of the company's existence, more than counterbalanced by the rise in workmen's wages, which was considerable towards the latter end of the decade. At the conclusion of these ten years it was evident that, on the whole, the cause of public order and morality had not prospered in Gothenburg, and many people were ready to pronounce the new system a failure. In the year 1876, however, a change set in, and the last fourteen years have been marked by a steady diminution:—(1) In the consumption of

* Over the United Kingdom the average expenditure on excisable liquor has risen during the last five years from £3 6s. 10d. to £3 15s. per head, or from £16 14s. 2d. to £18 15s. per family of five persons—an increase of 12 per cent. in five years.

† We must bear in mind that temperance work in Norway and Sweden has been carried on under great disadvantages: spirits are about one-third of the price we have to pay, and the sale of malt liquor is yet practically uncontrolled.

spirit per head of the population. (2) In the convictions for drunkenness (proportionately to the population). (3) In the number of cases of *delirium tremens.*"

The detailed reports received at this time from the British Vice-Consuls throughout Sweden, are, in the words of the report, "without exception, favourable to the system. In every case, except one, where statistical information has been supplied, the figures show a decrease in the quantity of spirits consumed, and in the number of fines for drunkenness, never less and often greater than is the case for Gothenburg. This seems to be of importance, showing that the scheme works quite as well when applied on a small scale as it does in such considerable towns as Stockholm and Gothenburg."

As the result of a considerable amount of investigation and examination of the literature on the subject, I am inclined to think that the Scandinavian system has been rather harshly handled by many who should have welcomed it as a step in the right direction. Norway and Sweden were at one time the most drunken nations in Europe, but, since the introduction of these systems, matters have undoubtedly improved. We cannot, however, take this as a ready-made system for adoption in our own country. Far from it. Many details are worthy of adoption, others indicate dangers to be avoided. Scandinavian experience seems to show that prohibition in rural districts is possible, but at the expense of increased drinking in the towns, where it cannot be stamped out. It shows that a certain amount of repression and restriction is undoubtedly beneficial, but that a time comes when this repression may advance too rapidly for popular opinion, and that in such cases the control of all the spirit licences may enable companies to gauge the actual wants of the people and adjust the supply to the demand, without stimulating that demand. The system mitigates insobriety under *all* circumstances, but, as already explained, it is not responsible for the variations in excessive drinking. The Scandinavian people as a whole are richer by some millions of pounds, which would otherwise have gone into the pockets of private citizens.

Broadly, the whole record may be said to prove that the system of eliminating private profit from the sale of drink is not only possible, but expedient; that the whole traffic may be undertaken successfully and efficiently by companies which modify their negative policy of control and restriction by the equally important

constructive policy of directly ministering to the welfare, comfort, and happiness of the people.

III.

Turning to our own country, we find Mr. Chamberlain in 1876 so ably and vigorously advocating the adoption of the Gothenburg plan that he convinced the Town Council of Birmingham and the local Board of Guardians of the feasibility of his proposals, and, in a letter written a day or two ago, he states that his views are still unchanged on the subject. His scheme differed from the Gothenburg method only in the municipalities working directly instead of through a company. It applied only to burghs; and the adoption of the scheme by the municipal authorities would have terminated the powers of justices to grant licences.

In 1879, after full examination of all the evidence then obtainable, a select committee of the House of Lords reported that the scheme was well worthy of a trial in one of our great cities.*

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* See Report of the House of Lords Committee on Intemperance, 1879. After setting forth the advantages and disadvantages of the Gothenburg system and Mr. Chamberlain's modification, the committee summed up thus —"We do not wish to undervalue the force of these objections; but, if the risks be considerable, so are the expected advantages. And when great communities, deeply sensible of the miseries caused by intemperance; witnesses of the crime and pauperism which directly spring from it; conscious of the contamination to which their younger citizens are exposed; watching with grave anxiety the growth of female intemperance on a scale so vast, and at a rate of progression so rapid, as to constitute a new reproach and danger; believing that not only the morality of their citizens, but their commercial prosperity, is dependent upon the diminution of these evils; seeing also that all that general legislation has been hitherto able to effect has been some improvement in public order, while it has been powerless to produce any perceptible decrease of intemperance—it would seem somewhat hard when such communities are willing, at their own cost and hazard, to grapple with the difficulty and undertake their own purification, that the Legislature should refuse to create for them the necessary machinery, or to entrust them with the requisite powers.

"It is improbable that in the first instance many boroughs would avail themselves of these powers. As in Sweden, the results of the experiment by one community would be prudently awaited by others. It might fall to Birmingham alone to furnish the experience which would determine other towns to adopt or reject so novel and vast an undertaking. If it succeeds, great public good will have been done; if it fails, the loss will affect only the community which has committed itself to the experiment.

"The committee, therefore, are of opinion that legislative facilities should

In August last, Bishop Jayne, of Chester, in some outspoken and well-reasoned letters to the *Times*, again urged that we should give a trial to the Gothenburg system, under certain modifications.

His policy is summarised in the following extracts :—"Licensed victualling must change hands. Experience has abundantly shown that private enterprise cannot bear the weight of this vast national responsibility. The State, through its local authorities and instrumentalities, must with a firm and liberal hand undertake the provision of houses of refreshment for the people, in which alcoholic beverages, though frankly recognised, will be deposed from their aggressive supremacy and supplied under less seductive conditions. These conditions would, for example, include comfortable, spacious, well-ventilated accommodation; temperance drinks of every kind brought well to the front, invested with prestige, and supplied in the most convenient, attractive, and inexpensive way; the pecuniary interest of the managers (*e.g.*, in the form of bonus) made to depend entirely on the sale of eatables and non-alcoholic beverages; alcoholic liquors secured against adulteration; newspapers, indoor games, and, where practicable, outdoor games and music, provided; while the mere drink-shop, the gin-palace, and 'the bar'—that pernicious incentive to drinking for drinking's sake—would be utterly abolished." * For the discharge of the duties thus sketched, Bishop Jayne is of opinion that the County Councils would furnish a machinery "free, on the one hand, from the dangers of over-centralisation, and on the other from the dangers of over-localisation."

At first the Bishop indicated approval of some form of pecuniary compensation to the publicans, but in his later utterances he explains his preference for what he calls "Consideration" for those dispossessed for the benefit of the community. This

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be afforded for the adoption of these schemes, or some modification of them. (Page 45.)

This clause has been sometimes quoted in support of the Local Option Bill; it doubtless favours the principle of entrusting communities with power to work out their own salvation, but the powers referred to are those of the Gothenburg system, including the removal of all private profit. A page or two earlier in the same report the committee had reported —"For these reasons the committee feel that they cannot recommend the Permissive Bill as a measure either of justice or of sound policy, or as likely ultimately to promote the cause of temperance to which its advocates are so earnestly and so laudably devoted." (Page 42.)

* *Times*, August 2nd, 1892.

consideration consists of giving the publicans some years' notice, and then, so far as possible, retaining them as managers, and buying up their stocks.

There the matter now rests. It is understood that a Bill will be introduced into Parliament next session dealing with details.

IV.

At the risk of being deemed a presumptuous interloper in a field where older and wiser men have so long laboured, and at the risk also of vexing many good friends, both in the trade and on the side of total abstinence, I would beg permission to state the broad conclusions which I have come to upon this most thorny problem. The subject has never yet received the full and fair consideration which it demands, and it never will, I fear, so long as its discussion is left to two warring factions, both comparatively small although well organised, but both equally unfitted for calmly weighing the issues. One, blinded by the magnitude of the evils to be remedied, desires to abolish alcohol in order to extirpate drunkenness; the other party, strongly banded together by self-interest, fights for dear life, and doggedly resists any encroachment or interference. The difficulty will be greatly intensified if liquor legislation is dragged down into the arena of party politics. This is eminently a question to be settled by "temperance" men in the true sense of the word. The great majority of us are not teetotalers. In this climate, with our fogs, chills, and colds; in this busy professional life, with its stress and strain; in the monotony and dreariness of the workers' lives, "with the hours of labour shortening and the hours of leisure lengthening," habits of moderate drinking exist which cannot be overturned in a day, or even in a generation. Intemperate abstainers deny that alcoholic beverages can be *used* without being *abused*; but if they were right, we should by this time be a nation of drunkards, whereas we are much more sober than our ancestors ever were. Temperance is largely a matter of education; total abstinence is largely a matter of constitution and of example.

Now, there is much reluctance amongst moderate drinkers to discuss this question at all; some abstainers are inclined to arrogate to themselves all the virtue and righteousness, and to class their opponents as defenders of the devil and his ways, as though moderate men could not be sincerely interested in the cause of

temperance. Why should any one hesitate to express an honest, strong, and thoughtful opinion in favour of the temperate use of alcohol, or why should he express that opinion in such an apologetic way that it is worse than useless? I say this in no querulous spirit, but to clear the air a little; for every fair-minded man willingly and freely admits that the unceasing and wide-spread efforts of the total abstainers have created the present public opinion which renders temperance legislation possible and probable. But moderate men and women form the majority of the electorate, and whatever *they* desire will become law. "High ideals are the very salt of our national life;" but when they are unattainable, is it not wiser to accept a compromise as a step towards those ideals? The ideal need not be abandoned.

If any progress is to be made, we must, *first*, frankly recognise that the total suppression of the sale of intoxicants in our large towns is impossible in the near future; and even in the country districts it is very questionable whether, if possible, it is expedient to entirely *suppress* the traffic. Such suppression would increase the attractions of city life, and there is already too strong an influx from country to town.

In the second place, while we are agreed that existing temptations and opportunities for over-indulgence must be curtailed, we find that the repressive policy cannot go beyond a certain stage without making matters worse, driving the evil deeper by placing it out of reach. Up to a certain point reduction of licenses means concentration of the traffic; beyond that point it means more drinking in secret, and illicit traffic, shebeens, and spurious clubs—forms of drinking which are most degrading, most debasing, and most fruitful of excess.

Thirdly. Upon what principle are the licenses to be reduced? Who is to solve this problem of limited suppression? Who is to undertake the difficult task of stating when restriction has gone far enough, and saying when the legitimate wants of the people have been met, and when they have been unduly fostered? Who is to undertake the most invidious and painful duty of deciding amongst rival publicans, each frantically and desperately pleading for renewal of his license? I say, let the whole trade change hands; let us have no more wrangling about the possession of these profitable shops. Let the city itself take them over, and determine the numbers and positions of all the houses. The good Bishop is undoubtedly in the right. Such a potent factor in the physical

and moral health of the citizens as the monopoly of the sale of intoxicants should not longer be left in private hands.

We have municipalised our water supply, our gas supply, our electric supply, and our tramway service. Whenever the interest of a monopoly becomes opposed to the interest of the community, that monopoly is sooner or later either controlled or carried on by the community. Let us, therefore, municipalise the public-houses.

Now, it is safer and easier to reform than to destroy the present public-houses. They are commonly regarded as nuisances, but they need not remain nuisances. The social instincts, as well as the thirsty appetites of the people, are satisfied by the public-house. The working man goes to the public-house really for hundreds of things besides a drink; he goes there for news, for discussion, for gossip, for genial comradeship; he enjoys cheerful, well-lighted, spacious rooms, where he has comfort and attention, where he can meet his friends and entertain and be entertained; *and, no matter what be said or done, he will satisfy his social cravings and meet his wants from his own stand-point.* That stand-point can assuredly be raised, but only through time. At present, however, he has to drink for the good of the house, whether he wishes to do so or not; he is tempted to drink more than is good for him, and spend more than he intended to spend. But get a good, reliable manager, take away the incentive to increase his sales of drink, pay him a large percentage of sales of non-intoxicants—let him even be a total abstainer himself. Make the primary consideration the preservation of order and decency and the development of attractions tending to temperance rather than drunkenness. Let the liquor be pure and unadulterated, and let there be temperance drinks, by all means, as rivals to spirituous drinks. With us in Glasgow there is not so much need to copy the Swedes, and insist upon food being also available, so well supplied are we, with restaurants selling low-priced, wholesome viands.

Did time permit, I would have described to you an experiment near Glasgow which has for many years been most successfully conducted on such lines. A good manager—preferably a total abstainer—is the primary essential.*

* The Workmen's Club at Thornliebank, established over ten years ago with the assistance of Mr. Alex. Crum.

Let me run over some of the clear *advantages* of adopting these suggestions :—

First.—The reduction of licenses would be affected without difficulty upon a general scheme, and in no haphazard way. Reductions would immediately follow a transfer of the traffic to the Corporation, as, on grounds of mere economy in management, all competing houses would be closed. Whether intemperance and consumption of liquor would diminish is another matter; I do not think they would *notably* diminish, at least for some time. On the other hand, the arrests for drunkenness might at first increase, as the managers and the police would act thoroughly in concert.

Second.—The police would be aided in many ways; the manager would tolerate no excess, but would strictly observe all regulations, enforce order, and prohibit gambling. Drunkards and criminals are most costly articles, and no corporation would aid in manufacturing them. At present they are the best customers to some of the publicans, who are, consequently, sorely tempted to condone their faults. Under the new regime "the orderly conduct of the house would be the first consideration, the sale of drink the last." The principle of "one man one license" would be thoroughly carried out, for each house would have a resident manager, while I am afraid that, under present conditions, "one man one license" would largely accentuate the growing danger of "tied" houses, and would really play into the hands of wealthy brewers and distillers.

Third.—All liquor would be perfectly pure, unadulterated, and well-matured, and inducements would arise to brew ale of less alcoholic strength than at present. We cannot complain much of adulteration in Glasgow, but in the mining districts around us the nature of the liquor supplied is simply scandalous.

Fourth.—Regulations in advance of general law could readily be introduced, such as early closing, raising the age at which young persons are supplied, &c.

Fifth.—All interested trade opposition in civic and parliamentary contests would disappear.

And, *Sixth.*—We could safely count upon considerably reduced intemperance, less crime and disorder, and a large surplus.

The only *objections* which I can imagine are :—

First.—The repugnance which many advocates of temperance may feel towards having anything to do with this disagreeable traffic

and towards participating in its profits. But "you cannot get rid of the responsibility by shutting your eyes; you cannot get rid of your participation in this business by pretending to wash your hands of it; you are at present undertaking the responsibility of its control and regulation, and the question is—Whether you will do that efficiently or in the perfunctory way in which it is now carried on."* Your choice lies between leaving these houses to persons who will try to sell as much drink as possible, or taking them into your own hands, with the distinct aim of doing nothing to stimulate demand for intoxicants, but to create other wholesome counter demands.

Second.—I do not think that we can ever get into the demoralised condition suggested by some people. I fail to imagine any Town Council or County Council deliberately fostering and increasing the consumption of intoxicants for the sake of additional profit. That could never happen unless, under the delusion that there was nothing left for it to do, the temperance party completely disappeared. The community knows full well how costly, in pauperism and crime, the traffic is, and the citizens are not so simple as to acquiesce in its extension. If the administration of the second city of the Empire cannot be trusted to do its very best to check excessive drinking, then I say any system must prove inoperative.

Third.—A final objection turns upon the vexed question of compensation. We can hardly discuss the subject minutely here, but, in any case, the difficulty would be much lessened if the Town Council took over the licenses. For my own part, I consider pecuniary compensation as now inadmissible; but, if deemed admissible, the profits of the trade would yield the necessary funds so long as the demands were not entirely exorbitant. There is the other alternative of fixing a period, a few years a-head, to which all licenses, not abused, would be allowed to run —on the understanding that at the end of that period the whole licensing system would be reorganised. Every effort would be made to minimise loss and inconvenience by taking over stocks, leases, managers, shopmen, &c.

We are rapidly approaching the time when we shall have a state or city *department for the entertainment of the people.* Our great cities are facing the necessity of providing abundantly innocent

* Joseph Chamberlain: *Fortnightly Review*, 1876.

and healthy amusements. I need not detail what has been done in Glasgow; but soon I think, we must have, in every district of the city, libraries, winter concert-gardens, as well as art galleries, and wholesome drama and opera. Music is an essential part of our national life, and one of the best counter attractions to the public-house. These attractions should not all be made free, but they cannot support themselves without aid from the city purse. Therefore, I say, to bring all this about, and to enable us to "pay the piper," while the public taste is being sufficiently raised and educated to make such schemes self-supporting, let us municipalise the drink traffic, control it and regulate it as it cannot be controlled or regulated just now, and out of the profit earned we shall provide the means of educating our citizens to appreciate the higher and purer pleasures—pleasures which, in time, will still the craving for intoxicants by gratifying the yearning for excitement, and grant relief from worry and weariness. "Drinking habits arise from misery, overwork, pain, monotony, and greyness of life; as these ills are removed the temptation to drink to excess passes away." Let the stream of drink profits be turned in upon itself as it were; let it be directed upon the consuming fire which yields these profits, till both die down together. Let the drink surplus pay for the counter attractions, and in proportion as these become self-supporting, the drink surplus will fall away.

I have not attempted to go into details, as, until some general agreement has been come to upon the principle of Constructive Temperance Legislation, it will be waste of energy to do so. But, so far as I know, there is no legal or technical difficulty in the way of carrying out such a scheme; it is very largely a question of detailed management. Glasgow will soon, probably, become a county, and its magistrates will fully control the licenses. If the city does not take over the traffic, there is nothing to prevent a public-spirited body of the citizens offering to do so, under guarantees that the business would be conducted in the public interest and in concert with the authorities. The annual profits would be enormous; and after paying interest on capital, and even compensation, if found expedient, the community would receive a dividend in gradually reduced intemperance, as well as a large annual surplus to be distributed in countless means for promoting the happiness and welfare of all.

I say to the total abstainers—give this plan at least a trial, give it only a fair chance; if it fails, your position will become

practically unassailable; if it succeeds, do not relax your efforts to promote temperance. The field will be as wide as ever, but the chances of success will be enhanced tenfold; the drink-seller, then a corporation official, will be upon your side.

I would say to all intelligent and broad-minded publicans—the law has now declared that you have no vested interest in your license; public feeling is intensifying against the trade you are carrying on, and is against compensating you for its suppression. Accept the position frankly, and aid us in getting some form of "composite consideration," if not an actual money payment. Do this, lest a worse thing befall you, as it befell the American slave-holders, who, after rejecting all offers of compensation, were ultimately compelled to abandon their so-called property without any return.

It is not only to such schemes as I have imperfectly endeavoured to outline, that we must look for increased sobriety; equally important factors are the spread of education and refinement, improved conditions of work and of home, and the consequent gradual rise in the standard of comfort. I am optimistic enough to believe that the infatuation for alcohol will gradually diminish, and ultimately so alter in character that intemperance will be confined to the hopeless, helpless residuum, which I fear we shall always have with us, as the standing enigma of our civilisation.

III.—*The Geography and Ethnology of Mashonaland, with a Brief Account of the Ruins of Zimbabwe.* By ROBERT M. W. SWAN, Member of the Archæological Exploration Party of Central Africa. *(A Communication from the Geographical and Ethnological Section.)*

[Read before the Society, 14th December, 1892.]

WE have all heard so many lectures on African geography of late, and the geography of all parts of that strange continent is so similar in general features, that it is extremely difficult to find anything to say on the subject which has not been said repeatedly before. An enumeration of the geographical details of a journey across the continent becomes extremely monotonous, for the various streams which one crosses are all alike, and the plains and forests are often for long distances of unvarying sameness. It is true that *travelling* across such a country may not be monotonous, but, on the contrary, extremely interesting, for one is often going over completely new ground—over a blank map, as we used to call it;—and then there is the pleasurable excitement of exploring, combined with the hope that every step in advance may disclose some startling landscape or important geographical feature. But the startling discoveries in a year's work may be very few, and in writing a narrative of a journey across Africa one may find very little to say that is worth telling. In our journey last year we did not make any very important discoveries in the country, although we found a few unknown streams and mountains. Our discoveries were principally made in the old maps, which we often found reason to correct. Our work consisted mainly in fixing latitudes, longitudes, and altitudes, making a running geological survey, and, I wish I could say, in correcting the orthography of proper names.

An enumeration of the foregoing points can hardly be made interesting, and I propose to describe to you to-night the method of travel in Africa south of the Zambesi, and to endeavour to

give you some picture of the country, the people, and their history, with no more of the geography than may be necessary.

African travellers may be divided into two classes—those who enter the interior by the country north of the Zambesi, and those who approach it from the south. The former class assemble a great number of carriers and form an armed expedition when they start from the coast, and are great and adventurous travellers; the latter class start in a waggon with about twenty oxen, and, perhaps, a rifle and shot gun, and wander into the interior. They are not travellers at all, they are merely "trekkers," and for about a year I was one of these.

An essential feature of South African travel is the bullock waggon, and how very useful it is one only realises when one has come to consider it as one's home. It is a curious structure evolved out of the brain of the early Dutch settlers at the Cape. It is exceedingly well and strongly made, has four wheels, is about 17 feet long, is sometimes half covered, sometimes entirely covered, by a tent roof, and carries about five tons comfortably. Thus loaded it is drawn by a team of 18 oxen, which are fastened by pairs to a trek chain. A good driver is essential, and his outstanding qualities are a ready command of very loud and strong language, and a knowledge of how to crack his long whip. When the waggon comes to a sticky place, every available team and every ox are yoked on, and the strength of the driver's voice and language are taxed to the uttermost. When these fail to extricate the waggon from the mud, it is unloaded and pulled out empty.

It is very pleasant, when the way is smooth, to be seated on the box of such a waggon, behind a waving sea of ox horns, and surveying a new country; but soon the waggon reaches a tree stump, and as the wheels go slowly, one after the other, over it, the jolting is disorganising. Then one comes to a river, and, notwithstanding the brake, the waggon rushes down the steep bank at a tremendous pace, and, if the water be not too deep, it is dragged through by the oxen. If the water is too deep, the waggon is unloaded, and everything has to be floated across. The waggon generally travels for four hours in the early morning, and for a similar length of time in the late evening. It is not prudent to work the oxen when the sun is high. In these eight hours the distance travelled will be from nothing at all to 15 miles. In the former case the waggon will be struggling in a mudhole, and in the latter one will have been forced to prolong the trek in order to reach water.

The long mid-day "outspans" or halts are always pleasant. There is time to do one's geographical work, and to study the zoology, botany, and geology of the place. The early morning treks are not so pleasant, but it is very charming to be going along into unknown country, over no road at all, on a bright moonlit night.

We all know that Africa, like Spain, is a great table land, with a strip of low country around the coast. We joined our waggons on this table land at Vryburg, and we had a long and somewhat tedious trek through Bechuanaland, and across a corner of the Kalahari desert, before we crossed the Shashi river, and entered that region which our countrymen seem to have agreed to call Mashonaland. Bechuanaland is fertile in some parts, but its towns are separated by great tracts of uninhabited land, so that one may travel for many days without seeing a native. What this country wants is water, and it would then be very fertile. Its most interesting geographical feature is its system of underground drainage. The water all flows at a considerable distance below the surface, either percolating through sand or sometimes finding its way through underground caverns. Sometimes the roofs of these caverns fall in, and then a great crater is formed on the surface. There are some such craters near Mafeking. The streams are generally sand rivers, and although they have wide, deep beds, one rarely sees water in them, for it is percolating through the deep sand with which the bed is filled. Generally it is sufficiently near the surface to be obtained by digging. We suffered considerably in the Kalahari desert from want of water; we even ran the risk of losing our oxen, and then we would have been in a deplorable plight indeed. The Bushmen women of that part obtain water by driving hollow reeds into the ground and sucking them. The water thus obtained they eject into gourds, and one drinks it—when one is very thirsty. But it is less objectionable than the water from many of the mudholes which one has to drink.

After crossing the desert one reaches the country of Khama, chief of the Bamangwato tribe. He is a most interesting man and an extraordinary phenomenon amongst savages. The missionaries had influenced Khama's mind in his early youth, and induced him to conform to certain civilised customs regarding matrimony, witchcraft, &c. His father, a savage old chief, was determined that Khama should practise the heathen customs, and the result

was that Khama had to flee, and then a long-continued war went on, like that between Saul and David—Khama constantly refusing to harm his father when he had him in his power, and the father always thirsting for his son's life. At last his father died, and Khama is now probably the most powerful native chief south of the Zambesi, with the exception, perhaps, of Lobengula, whose power, supported by cruelty, is on the wane. He is now a man past his prime, but is still most active, and the best horseman of his tribe. His face is one of striking intelligence, and his mind does not belie his face. He rules his people in a truly patriarchal way, considers what is best for them, and makes them do it. He clearly understands the dangers of alcohol to negro blood, and he does not allow it in his country. He is most friendly to every Briton, but woe be to any who bring spirits into his territory. They will at once be transported over the frontier, and be forbidden to return. Khama has even stopped the use of the harmless, weak, native beer. His people would hardly stand this, and they threatened his life, but he enforced his will all the same. Lobengula has often tried to raid on his territory, but Khama has always managed to repulse even the warlike Matabili. He administers justice with a firm hand, and, when crime is clearly proved, punishes with great severity. One need never fear to lose an ox in his territory, for it will be sure to be restored. He enjoins hospitality to strangers, and travellers have presents of food made to them in his country. The removal of his people from the waterless Shoshong to the well-watered Palapwe was accomplished with marvellous celerity, and without hardship to any one. The wealthy were made to assist the poor, and to assist the aged and infirm. We had most pleasant relations with the chief, and we well remember how he came to our camp very early one morning to negotiate some business with us, and we had to receive the king and hold our levee in our nocturnal garments, while he was clad in European costume.

After we left Palapwe we entered a country with a much better watered surface than Bechuanaland, and soon after crossing the Shashi river we were in a land of frequent, clear, running streams. At the 'Mshabetsi river we were at the lowest altitude which we touched till we reached the Pungwe river, near the Sofala coast. It was 1,720 feet above sea level. We then ascended continuously until we reached Zimbabwe. The lower country between Palapwe and the higher plateau at Zimbabwe is,

in most cases, thickly wooded, and it is at about this altitude of 2,000 or 3,000 feet that the gigantic baobab tree flourishes in that latitude. We found some of these trees attaining a girth of nearly 100 feet at a short distance from the ground. Here the mopani tree also flourished, and one travels for weeks through its thick forests without ever seeing a distance of a hundred yards on any side, except when one ascends some bare granite hill. By the Limpopo river there are dense thickets of thorny mimosas, and I well remember a long day's ride I had through such bush, for I reached camp with the loss of nearly all my scanty clothing and much of my blood.

When we had ascended through the gorge which has been called "Providential," we saw stretching away before us a beautiful, open, grassy country, broken by lovely mountain ranges. Our eyes had grown wearied of the curiously grotesque outlines of the granite hills of the lower plateau, and we hailed with delight the graceful outlines of the hills around Zimbabwe.

We stopped two months at Zimbabwe, and had a most busy and interesting time excavating among the ruins; and then we started on a riding expedition to an unexplored part of the country down by the Sabi river. We were told that we should find hostile tribes there, and were advised to increase our following; but we had learnt to despise the warlike prowess of the Kaffirs, and found that, if we only treated them like children, they never fought. Hearty, explosive laughter was more effectual than gunpowder, and I remember how we discomfited the chief Ikomo when, with shield on arm and poised assegai, he threatened our lives if we approached the ruins. While we laughed our lady companion obtained, with a detective camera, a good photograph of the young man in his striking attitude. At the Sabi river we found no one to laugh at, for the country was uninhabited. The position of the river was of interest to me, for there was reason to believe that it was seriously misplaced on our maps, which were the most accurate we could obtain in this country. To reach it we travelled two days more than we expected, and I remember the keen excitement with which at last we saw the gleam of its waters through the forest, and how, thirsty as we were, we rushed to its banks and drank, and were disappointed that our great thirst was so easily satisfied. I found that it was 25 miles further east than the maps made it, and more southerly, in the latitude of Zimbabwe, the maps must have it about 35

miles out of position. From the Sabi river we went to Fort Charter, and thence, over an uninteresting, woodless, swampy, high plateau, to Fort Salisbury, our altitude gradually increasing until that place was reached at an elevation just short of 5,000 feet. From Kanya, in Bechuanaland, to a point a little beyond Charter, we had crossed streams which drained into the Sabi and Limpopo rivers, but at this point we crossed to the other side of the watershed, and encountered streams which flowed to the Zambesi.

At Fort Salisbury we finally left our waggons, and, marching and riding, we travelled to the redoubtable Mtoko's country. We were bearers of the first instalment of a yearly present from the Chartered British South Africa Company to this great warrior, and we looked forward to a pleasant reception. We were again in an unmapped and unexplored country, and to us the geographical interest of the expedition was great; but, as I have said, interest in such an expedition fades with its accomplishment. Only with great difficulty could we induce any bearers to accompany us into the territory of the great warrior, for all his neighbours feared him. He had beaten the Portuguese in battle, and was arrogant and worse to his neighbours. They prophesied trouble to us, but we trusted in our luck and our laughter, and also somewhat in our present. We at last reached his country, and we three proceeded on foot to his kraal. We were rapidly ascending the hill to his place, when we were met by a dignified herald with uplifted assegai, who commanded us to stop and at once to retire one day's journey distant, and to remain there until the Mtoko had sent for us. In the meantime our pack asses had arrived at the foot of the hill, and been partly unloaded, and so we refused to move. We sent word to the Mtoko that we had brought him a great present, and that if we retired at all we would retire altogether, and would take the present with us. Towards evening we compromised the matter by retiring about half-a-mile away, across the first stream—the Mtoko sending to explain that he loved us, but that it was an ancient law of his people that he could see no great strangers until his Indunas in council had first given their consent, and that he was, therefore, forced to ask us to retire. After much negotiation and many threats on our part to go away with the present, his majesty came to see us at the head of a band of warriors, and surrounded by his Indunas. At first he would not receive the present, sayingthat

it had been bewitched by the white lady, who had come expressly for that purpose; but it was explained to him that he was very foolish to have any such idea. Then he approached, but would not sit on our blankets, and, during the whole indaba, sat on his heels and nervously peeled a raw potato with a battle-axe. The various parts of our present were separately handed to him, and their values explained, or rather enlarged upon. Compliments were then exchanged, and the indaba was broken up, soon after which our hearts were made merry and our appetites appeased by the present of a full-grown cow, and a native lady's diminutive costume. We ate the cow in a marvellously short time, but as for the costume we had no great use for it. We were now free to wander about the place, and I ascended a hill and sketched the topography of the country. After a visit to the royal kraal, and also to that of the high priest or Mondoro (who told us that he was the true Mtoko), we left this interesting country with regret.

We passed through Mangwendi's country, and, crossing several of the eastern tributaries of the Sabi, we entered Makoni's country. From here to Mtasa's our way lay over a very rugged country—the edge of the high plateau—consisting of granite mountains of the most fantastic shapes. We crossed the Odzi river, and here I ascended Mount Yenya, which is, with the exception of Mount Wedsa, near the Sabi river, probably the highest peak in Mashonaland. Its height is 5,800 feet. It seems to be the mountain which the Portuguese call Doé on their maps, and which they say is 7,000 feet high; but certainly there is no mountain in this part of the country of that height. We visited the kraal of Mtasa, the chief of Manika, and a truculent rascal he is. He tried to play a fast-and-loose game between the British and the Portuguese, but the Chartered Company were too smart for him. We reached Umtali, and rested there a short time while we reorganised our little expedition for a march over the low country to the coast. Umtali is at an altitude of 3,600 feet, and Massikessi, only eleven miles farther east, at 2,200 feet. In passing between these two places we had descended from the high plateau and got into a very different climate. On the high plateau the climate is temperate, but at Massikessi it is tropically moist and warm, and there one finds the banana and palms growing luxuriantly. We did not lose much more in altitude until we approached Sarmento, on the Pungwe river, and then we were nearly at sea level, and our way lay over an alluvial tract to the coast.

The geology of a country is closely connected with its geography, and this is especially true of Mashonaland, for there one finds that the geographical features of the country change very much when one crosses from the granite on to any other formation. The geological—or, I should say, mineralogical—nature of the soil affects the vegetation very markedly in Mashonaland, and when we pass from the granitic to the quartzitic and schistose formation, a change is at once apparent, even in the lower forms of vegetable life.

With the exception of a small part of the south of the country, all parts of Mashonaland which I visited consist only of two kinds of rock formation—of granite and metamorphosed sandstones and shales. These now appear as quartzites and schists. Crystalline limestone is sometimes, but rarely, present, and I only remember observing some near the Sabi river. Magnesia is present, notably in the soap-stones at Zimbabwe, and also around Umtali.

The surface of the granite is generally pretty level, except where groups of isolated little granite hills rise through the plain. These hills are most remarkable and varied in form. They sometimes attain an altitude of 1,000 feet above their base, but more often they are about 400 feet high. Generally they are composed of enormous broken blocks of granite, but often they are dome-shaped and of one unbroken mass of rock. The summits of the latter kind of hills are, of course, quite inaccessible. They are not hills left in relief by the denudation of the surrounding country, but, judging from the exposed sections of some that I have seen, they have been elevated by a force acting at a comparatively small distance below the present surface, and they are older than the stratified rocks of the country.

On the granite plateaux patches of the stratified rocks that I have mentioned—that is to say, schists and quartzites—are met with. The strike of the strata is generally east and west, and the various patches of rock roughly range themselves in this direction, so that they form a series of belts traversing the country. These semi-continuous deposits or belts are generally a few miles wide, and in them occur the gold-bearing quartz reefs. The deposits are all fairly similar in nature, and, probably, represent a continuous sheet of stratified rock, all of which has been denuded away except these belts. The mineralisation is everywhere fairly similar, and in all parts one encounters great masses of magnetite and henatite, which render compass observations untrustworthy on the quartz

formation. Manganese is also often present, and the gold-bearing quartz reefs seem to be distributed over the stratified rocks in all parts.

The vegetation of the country is most interesting, and would well repay the study of botanists. In parts of the Kalahari desert, where it sometimes does not rain for several years at a time, and where hardly any dew forms, there are found only hard-leaved grasses and plants of the cactus kind, from the surface of whose leaves evaporation is extremely small, and which are, therefore, capable of growing with a very small supply of moisture. The way in which vegetation in all parts of Africa adapts itself to extraordinary climatic conditions is most remarkable, and were it not for this character of the plants there, the Kalahari would be entirely devoid of vegetable life, for none of the plants of Mashonaland and other well-watered parts would grow there. In the district between the Lotsani river and Fort Victoria the mopani tree grows in great forests, which extend for hundreds of miles. It has a sort of double leaf, which it expands freely when the sun is low, but long before mid-day, when evaporation is rapid, the double leaves fold together, so as to expose only half of their surface to the sun's rays, and thus limit the evaporation of moisture from their surface. Euphorbias flourish best in this latitude, at an altitude of about 3,000 feet, and they are found growing to an enormous size. At this altitude there are also great tree grasses of a most curious appearance, looking like diminutive leafless trees with tufts of grass placed at the tips of their branches. At about 3,500 feet altitude a nearly bare country is reached, when the only common tree is a smooth-barked one, whose name I could not learn, but which is chiefly remarkable as being the habitat of a kind of hairy caterpillar, which the Kaffirs collect in great quantities and eat. They say it is a substitute for salt, but how it acts in this way I cannot say. This same tree has a tough fibrous bark, of which the natives make thin cloth. At this 3,500 feet altitude the bracken flourishes, and also the tree fern, and I was much astonished when I found on the bank of a little stream near Zimbabwe the bracken, the tree fern, and our own *osmunda regalis*, growing side by side. Lichens also grow plentifully, and hang in great waving tendrils from the trees, and the weirdest forest effect I ever saw was in one of these woods. It was winter time and there were hardly any leaves on the trees; but the whole air seemed filled with a

delicate network of tendrils of an apple-green lichen, which coloured the atmosphere and gave everything a ghastly appearance. The many flowering trees of Mashonaland are worthy of notice, and I know of no more gorgeous colouring than that of a great Kaffir baum tree covered with its scarlet flowers, which are in full bloom before the leaves break forth. Coarse grasses grow twelve feet high, and so thickly that the traveller can hardly force his way through them; and another grass sheds its barbed seeds on one's clothing. These soon find their way through into one's flesh in great numbers, and give much annoyance.

In Mashonaland it is most remarkable how the vegetation changes its character as we pass from the granite to the quartz formation; the coarse grasses are at once replaced by finer ones, and by beautiful flowering plants, while the bushes and trees increase in variety. I am of opinion that we shall find the granite soils feebly productive and easily exhausted, and by far the best agricultural part of the country will be on the quartzitic formation. The natives of Mashonaland nearly always have their villages on the granite, and hardly ever on the quartzitic formation, and a few villages in the Mazoe valley are all that I know of on the latter. The reason for this is probably that the granite hills are more abrupt and easily defended than the others. The people hardly ever till the same patch of ground for more than two consecutive years, and they are constantly clearing the bush and opening up new fields. When they have used all the ground within a convenient distance of their village, they abandon it, and migrate to another part of the country. Such change generally seems to take place about once in a generation.

A remarkable feature of Africa—almost a geological one—is its ant-hills. The ants seem there to fulfil the same functions as earthworms do elsewhere. Earthworms are practically unknown in the country, and the turning over of the soil is done by ants, which transport an enormous amount of soil to the surface. One naturally ascends an ant-hill in Africa when a view of the country is wanted. They yield the most fertile soil, and are covered with trees; and if, when passing through a forest, a denser mass of foliage than usual is seen, one rightly concludes that it is growing on an ant-hill. The ant-hills formed by different ants are different in shape and size. In the Karoo we meet with very numerous hemispherical hills, about two feet high, and with a very hard surface. Further north the tall, spire-

shaped ant-hill is encountered. These are often about 20 feet high, and have a chimney down their centre. The soil of which they are composed sticks firmly together. They are very steep near the top, so that one can only climb them by clasping one's arms around them. They are generally built around a rotten tree stump. Then there are the conical-shaped ant-hills, and they are sometimes nearly 40 feet high. The biggest ant-hills which I saw were near the Hanyani river, about 30 miles south of Fort Salisbury, and I estimated the cubic contents of one of these at 1,500 yards, or, say, about as many tons.

The meteorology of the high plateau is interesting and extraordinary. Over the dry Kalahari desert we experienced many electric storms; in fact, almost every evening there were brilliant displays of summer lightning. At Zimbabwe, I took continuous readings of the wet and dry bulb thermometers, and the barometer for the two months of June and July, and these give us a fair idea of the climate at that time. During the first week we had south-easterly winds, a high barometer, and rain and mists. The wind then fell, and the barometer with it, and we had three weeks of fine calm weather. The barometer reached its minimum on June 27, and at the same time the difference of the readings of the wet and dry bulb thermometers was at its maximum—that is to say, the air was driest with a low barometer. The sky was then clear with light north winds, which were evidently local in origin, and the temperature at night fell below freezing point, so that in the morning we saw a light deposit of hoar frost. Immediately after this the barometer began to rise, there were light south-easterly winds, the atmosphere became moister, and on the 4th of July the south-easterly winds had increased considerably in strength, and some rain fell. From this time until the 2nd of August the barometer slowly rose and fell, its range being limited to three-tenths of an inch, and whenever the south-easterly winds blew at all strongly the barometer rose, and we had mist and rain.

At first sight it seems surprising that we should have windy wet weather with a high barometer, but we must remember that the only winds which can bring rain to Zimbabwe, at least in winter, are the south-easterly winds, and these, like all winds blowing towards the equator, increase the atmospheric pressure. Zimbabwe is situated on the edge of a plateau about 3,400 feet above sea level. The country breaks down gradually towards the south and east, and more rapidly towards the west; while

towards the north it rises gently until, after about 100 miles, it attains an altitude of 5,000 feet. The west winds, if they do blow, have to traverse the continent and high country, about the sources of the Limpopo, before they reach Zimbabwe, and the northerly winds would tend to increase in temperature after falling from the high country towards the north; so that neither of these winds will deposit moisture at Zimbabwe under ordinary circumstances. The predominant winds in this latitude are the south-easterly trades, and they, carrying their moisture from the Indian Ocean, are forced to rise as they pass over this country, and they consequently expand and are lowered in temperature, and so deposit much of their moisture on this edge of the high plateau. A similar winter climate seems to prevail in most parts of Mashonaland, the edges of the plateaux receiving most of the moisture. Manica is situated much nearer the sea than Zimbabwe, and the country there falls much more rapidly towards the east, and consequently the rainfall there is heavier. Fort Salisbury is better situated for a dry winter, for it is in the middle of a high plateau, and the south-easterly winds will have parted with most of their surplus moisture for that altitude before they reach it.

We are too apt to regard only the Mediterranean Sea when we think of ancient navigation, and to imagine that all early maritime commerce was confined to its shores. Our civilisation is essentially based on Hellenic civilisation, and we are too ready to disregard that of other early races. Classical writers tell us much of the navigation of the Mediterranean, and hardly ever mention the ships of the people who lived beyond its shores, and these people have themselves left little of literature behind them. But sufficient has come down to us to show that there was an extensive extra-Mediterranean navigation at a very early period, as well as in classical times, and even in the Middle Ages. The Phœnicians, from their early homes in the Persian Gulf, doubtless coasted along the shores of Asia; and the inhabitants of South Arabia, at a still earlier period, crept down the east coast of Africa. Their navigation, like that of the Mediterranean peoples, was doubtless carried on within sight of land, but it would be favoured by more regular winds than those which prevail on the Mediterranean. Their navigation was important until after our era, when it declined, but it was revived after the Mahommedan era, and was of great magnitude in the golden days of Bagdad,

when the Caliph Haroun al Raschid listened to the tales of Sinbad the Sailor. Shortly after this El Masoudi made his travels, and Edrisi wrote his geography. When the Portuguese sailed round the Cape of Good Hope in the sixteenth century Arabian navigation was again declining, and they seem to have given it its death-blow.

Neither the Portuguese nor the later Arabs seem to have settled in the interior of Africa. They both occupied places along its coasts, such as Sofala and others, and the Arab merchants penetrated inland and carried on their trade with the natives, much as the Arabs of Zanzibar do at the present day. But at a very early period the inhabitants of South Arabia seem to have settled in the interior, and erected temples and other buildings there. Such were the ruins which we found at Zimbabwe and elsewhere in Mashonaland. Our primary object in visiting Mashonaland was to examine these ruins, and we devoted two months to measuring them and excavating around and within them. The results of our labours we have published elsewhere, but a few words on the ruins will, I hope, interest you.

You have here a plan of the most important one—the great temple at Zimbabwe. This is the building which Herr Carl Mauch says was built by the Queen of Sheba on the same plan as the temple which Solomon built on Mount Moriah; but you who have read the Chronicles of King Solomon will not, I think, agree with Mauch. We must, however, do Mauch all honour as the first scientific man of modern times who visited these ruins; but we must also remark that he did what no scientific man should do—he allowed his imagination to run away with his judgment. I must beg you to disconnect in your minds all ideas of the Queen of Sheba and these temples; for while they were built by people of her race, they were doubtless built long before her time. Her people probably obtained gold from the coast, but before her time it is also probable that they had abandoned their settlements in the interior of the country. This temple measures about 280 feet in its greatest diameter; its outer wall is about 15 feet thick at base, 10 at top, and 28 feet high. It is built of little unhewn blocks of granite, with marvellously regular level courses, and on most carefully executed curves. The batter of the walls is extremely regular, and it is worthy of remark that the builders have made the batter considerably less on the inner surface of the curve, where it was less needed to give strength,

than on its outer one. Parallel to the outer great wall is an inner one, which originally seems to have been nearly of equal height, and the narrow passage between the two leads to the two towers which were the central objects of worship, in the form of nature worship, which was practised at Zimbabwe. These towers had the same meaning as the columns which Lucian describes in his "De Dea Syria," as the sacred tower of the Midianites, called Penuel, which Gideon destroyed, or the pillars in Solomon's temple, called Jachin and Boaz. They also find parallels in the conical stones set up in Phœnician temples, and in the lingams of India.

I will not go into the extraordinary mathematical construction of the temples now; suffice it to say that the cubit was used in the construction of the great tower, and that the diameter of this tower, multiplied by a number representing the ratio of the circumference of a circle to its diameter (which is also the ratio which the diameter of the one tower bears to the other) has determined the lengths of the radii of all the curves in all the original walls of all the temples in Mashonaland. The position of the towers also determined the orientation of the temple.

This temple was also devoted to solar and to stellar worship, and in connection with this latter cult accurate observation was made of the motions of the stars. At Zimbabwe only stars of the northern hemisphere were observed, and they were only observed when crossing the meridian at their upper culminations. The stars were thus observed by means of lines of sight directed true north with great accuracy, and I hope yet to show that the extreme limit of error in laying down these meridian lines was not more than 15 minutes of a degree. This would argue a possession by the builders of extremely accurate methods of observation.

I have shown elsewhere that the style of masonry of Zimbabwe is clearly distinct from, and is opposed to, that of the Phœnicians, for at Zimbabwe we have a careful laying of the stones in even courses, and a great uniformity in the size of the stones. On the contrary, the Phœnicians seem always to have disregarded uniformity in the size of the stones they used, and never to have built their walls in courses until their architecture was influenced by that of the people around them, and then they used carefully squared stones. Neither does the plan of the temple nor its mathematical construction resemble those of any known Phœnician

temple. The observation of stars on the meridian, and never on the horizon, is clearly distinct from the methods of observation used by any ancient people with whose astronomy we are acquainted, and seems to refer us to a race which did not inhabit an open level country, like Egypt or Mesopotamia, but a hilly country, with an irregular horizon, such as South Arabia is. The South Arabians are the only people we know of who could build the temples of Mashonaland, and the little we know of them seems to connect them with the ruins. At a very early period, indeed, they were a great trading, maritime people, and in the time of Queen Hatasou, of the eighteenth Egyptian dynasty, they did possess articles which can hardly have come from any other place than South-Eastern Africa. Prior to her time the dominant Arabian people seem to have been the Mineans, and after her time the Sabeans were in power. We know that she conquered Pount, which was almost certainly South Arabia, and it is probable that at this time of disturbance the South Arabian dynasty changed from Minean to Sabean, and that the connection with South-East Africa was broken, and not for a long time, if ever, did the Sabeans settle in the interior of the continent. The objects which we found in our excavations were mainly Phœnician in character, but there is nothing to show that these objects are as old as the temples. Some of the walls of the temple were presumably rebuilt by that people, for these walls bear evidence, in their plan and construction, that they had not been erected by the original builders of Zimbabwe. There is good reason to assume that these re-builders were contemporaneous with the expedition which Herodotus tells us Pharaoh Necho sent in Phœnician ships to circumnavigate Africa.*

Apart from intrusive Europeans and Arabs, the present inhabitants of Africa south of the Equator belong to two races—the aboriginal Bushmen and the Abantu tribes. These Bushmen are probably the dwarfs whom Herodotus mentions whose language was like the singing of birds, and they are also the dwarfs of the Congo forests. They vary greatly in size, and in the colour of their skin, but their language all over abounds in the peculiar consonantal clicks which the father of history probably thought was like the singing of birds, because he could not under-

* For further details of the ruins, and remarks regarding their history, see a paper in the *Proceedings* of the Glasgow Archæological Society.

stand it. They are a curious race, and are rapidly diminishing. As civilisation advances they retire into the forests, and live on the spoils of the chase. They are adept hunters, and with their poor weapons they do not hesitate to attack the most savage beasts of prey, and even the lion himself often falls a victim to their cunning. They seem to have given names to most of the natural features of the country, as the rivers and mountains, and these names have been adopted by the later-arrived Abantu tribes. We may, I think, assume that the names which contain click sounds are of Bushmen origin, as, for instance, 'Mfuli for river; Nyatzetzi, Nyanza; and probably even the name of the Nile itself in its original form, for near its source in the Victoria Nyanza we find it called, as the ancient Greeks used to call it, Nylos.

In Africa, north of the Zambesi, we find such sounds preserved in a manner, as in Mpwapa. Our maps of Southern Africa ignore these sounds, and we write Inyambane and Umtali, instead of Nyambane and Mtali. Were the names of the great lake and the Nile treated in the same way, we should call them Inyanza and Inylos. But when bad orthography gets hold of place-names correction is hopeless. The name Makalanga, which has existed since at least the sixteenth century, has recently been replaced by Mashona.

Occasionally, under overhanging granite cliffs, paintings are found all over South Africa, representing wild animals and hunting scenes, and it is generally, and, I think, rightly, assumed that these have been made by the Bushmen. They are generally in one colour only, which may be either black, dark red, or yellow. The colouring matter used is generally an ochre, and seems to have been put on with oil. Some paintings are doubtless very old, and are practically indestructible. In one cavern we found drawings of three periods, the one being superimposed over the other, and the older drawings being by far the better ones. From an artistic point of view these old drawings are wonderful. They recall in their realism the drawing of the mammoth found on a bone in a cave in Dordogne, but they are better executed. These are the only antiquities the Bushmen have given us.

The origin of the Abantus, the other people who inhabit Africa south of the Equator, is wrapped in mystery. They are a woolly-haired race, and have not always the thick lips of the true negro, nor is their colour so dark as his. They are not black, but are of a dark reddish-brown colour.

All over this vast extent of country there is a great uniformity in language, so much so that, knowing only one of their tongues, one may travel almost anywhere among them and make oneself understood. This uniformity of language is maintained by a constant intercourse between tribes all over the country, for they are great travellers, both individually and as tribes. Kaffirs will think nothing of going a thousand miles or so on what we would consider a very trivial errand. They travel with an assegai and a cooking-pot from village to village on foot, and seem to get hospitality everywhere. All Africa—at least in all inhabited parts, and that is nearly all well-watered parts—is traversed by a network of paths which wind around minor obstacles, but proceed with great general directness to their destination. Along these the Kaffir travels with great celerity, and easily accomplishes twenty miles per day even when carrying a 50 lb. load.

In many of their customs the Abantus show traces of foreign influence. They sometimes dress their hair in a most elaborate manner with beads and grease, and as this involves some days' labour, they are careful to preserve it from being disarranged, and rest their necks on curiously-shaped pillows when they sleep. Exactly similar pillows were used by the ancient Egyptians for their mummies. The Kaffir piano, which is a collection of iron keys fixed on a board and placed inside a gourd which acts as a sounding board, finds a parallel in Nubia and Lower Egypt. Kaffirs tattoo their stomach in a similar way to that which one finds represented in Phœnician remains. Their beer, doro or durrah, made from millet, they have in common with the Abyssinians and some ancient nations. A game called isafuba, which has practically become the national game of the Makalangas, is of Arab origin. Many of the more refined looking Kaffirs seem to have some Arab blood in their veins.

Their system of government is patriarchal, and in theory the chief possesses everything; but in practice, private property is owned, and each wife of a chief seems to preserve separately the produce of her particular field, and, probably, for the use of her own offspring. These and the following customs are, perhaps, of Arab origin; but they are also such as the Kaffirs would acquire from their semi-nomad polygamous life. Each tribe is called after its founder, with the prefix Ma or Ba before his name—thus we have Makalanga, Bamangwato, &c. As soon as a woman has a male child, she drops her own name and adopts that of her son, with

the prefix of Ma. The chiefs have dynastic names, like the Pharaohs and the Cæsars, and the tribal name sometimes becomes the dynastic name, but not often. Thus at Zimbabwe the dynastic name was Mgabi. The present Mgabi will be succeeded by his brother, who will then take the name of Mgabi. Sub-chiefs have also sub-dynastic names, as Mangwendi and Gatsi, who will become Mangwendi when he succeeds his brother.

El Masoudi, writing in the tenth century of our era, speaks of the Zenj tribes (the Abantu people, who gave their name to Zanzibar), and his description of them answers to that of all the Abantu peoples of to-day. He speaks of a descent of this people, but, probably, he only refers to such a tribal movement as has been common in their history in modern times. Such movements are among the most interesting things in their history. A number of tribes may exist in juxtaposition for several generations, and be preyed upon by their neighbours, until some day a strong man arises among them and organises them in a military manner, and then they move on and conquer new territories. The Zulus made such a movement from the north, probably some time in the last century, and crossed the Zambezi and Limpopo rivers, and passed down south into Zululand. They probably broke up some minor organisations on their way, and in Mashonaland annihilated the last of the Monomotapa power. Their organisation culminated under Cetewayo, and in a generation or two more would probably have declined even had we not interfered. In this century a band of them broke off under Mzila, and founded the Gaza kingdom, east of the Sabi river; and another band, under Mzilikazi, marched north, and formed the Matabili power. The latter has been more warlike than the former, but its decline seems to be more rapid. The Matabili people tell their king, Lobengula, that he should conquer a new country for them, as his father did; but there is no new country left for him to conquer. The most remarkable Kaffir organisation or empire that we know of was that of the Monomotapa, who ruled over the Makalanga people. Their dominion seems to have extended from the coast to about 31° E. long., and from the Zambesi to the Limpopo rivers. The early Portuguese historians of the country give us much information regarding them. Dos Santos enters most into detail, but the power of the Monomotapa had passed its zenith before his day, for a preceding Monomotapa had sent three of his sons as viceroys to different parts of his territory; and, when the

father died, each of these three had continued to govern independently his own province, so that the ancient power was broken up into the kingdoms of Kitewe, or the Sofala district; Chihanga, or the Manika district; Sedanda, or the Sabi district; and the Monomotapa district proper, which probably lay along the Zambezi, and seems to have preserved its name to Livingstone's day. Then the Zulus, moving south, seem to have conquered all the people who were in their path; and the Matabili division, moving north again, subjugated these Makalangas completely, and reduced them to the condition in which we find the people of Mashonaland to-day. The warlike spirit has completely gone out of them, and they hardly attempt to defend themselves in their almost inaccessible hill villages when Lobengula's people come to raid. But the people who were not directly in the path of the Zulus were not subjected to the same hardships; and in the east of the old Monomotapa kingdom we find tribes still preserving something of the old independence—such, for instance, are Mangwendi's and Makoni's people, and especially Mtasa's and Mtoko's people. These two last have at times been more than a match for the Portuguese, and Mtoko's people are probably as good warriors as the Matabili themselves. Their villages are not built on the top of rocks, like those of the tribes further west, but in places without any great natural defence, and they trust to their own valour to preserve their property.

Dos Santos gives us much interesting information regarding the Makalangas when under the rule of their Monomotapa emperors. He tells us how they worshipped a supreme spirit, whom they called Muali, and that they had feasts in honour of their dead at new moons, besides many days of rest which the king appointed for the worship of their Mozimos or ancestors. The spirits of their ancestors do not go to heaven, but only Molungo or Muali is there. Good spirits seem to sojourn in a sort of elysian fields, while the bad ones becomes Mashuvi or devils, to work woe in the world. He naively says that these Kaffirs know not of the creation of the world, nor that God made man, nor of hell for the bad, nor of glory for the good. They buried their dead wrapped in a cloth or mat, and in a sitting posture, with a little millet seed and a water pot. He described their witchcraft and divining customs, and mentions the three fairs or markets which they had at Massupa, Luanze, and Manzovo, at which they traded with the Portuguese. He tells us of their gold-mining customs, and of

how they got gold by washing alluvial and by searching the streams for nuggets after rain. Before Dos Santos' time these Makalangas doubtless mined the quartz reefs, and crushed the quartz in the many stone mortars which yet lie scattered about the country; and they seem to have winnowed the crushed quartz when they had not water to wash it. But the Portuguese had already sent two expeditions into the country to conquer the mines, and they had been repulsed after severe fighting. And Dos Santos describes how the Monomotapa ordained that when a Kaffir discovered a mine of gold, he should at once publish the fact on pain of death, not taking any gold, but must cover the gold with earth, and must cut a great branch of a tree and place it over it, so that other Kaffirs might be warned not to approach it on pain of death—and all this to guard against the cupidity of the Portuguese.

In the customs of the Monomotapa empire we seem to detect a good deal of Arab influence, and we must remember that, when the Portuguese arrived on the east coast, they found the Arabs there in considerable force, and had a struggle with them for the possession of Sofala. These Arabs understood the customs of the blacks better than the Portuguese did, and passed into the interior of their country on trading expeditions as the Portuguese hardly seem to have done, but probably just as the Arabs of the Sofala coast do to-day. The Portuguese Jesuit missionaries penetrated to the court of the Monomotapa, and boasted that they had converted the Emperor to Christianity. The Arabs were jealous of their influence, and intrigued against them, and had the missionaries destroyed, and so the battle of the faiths went on, probably much to the edification of the negro chief. Now this history repeats itself in Uganda. The Arabs have certainly left a broader mark on the people than the Jesuits.

The present tribes are extremely reticent about their superstitions and religious customs, and it is only with great difficulty that one can gather any information on this head, but anything that one learns confirms what Dos Santos has told us of the Makalangas of his day. They recognise one supreme spirit, whom they call Muali, and sacrifice to the spirits of their ancestors, and the chief decrees cessation from labour on certain days during the sowing season, and these days they call Muali's days. They bury their dead on a mat, with a pot and a little grain beside him, but what their ceremonies at burial are they carefully concealed from

us. We found many of their graves when excavating at Zimbabwe; and when we thought that we had at last found some genuine remains of the forgotten race, we were extremely disappointed and disgusted when some one of our workmen told us that the bones were those of one of his relations.

The Kaffir huts are all made of wattle and daub. Some of the people still build walls in poor imitation of the original temple builders; but these walls are nearly always fortifications, and one finds them most abundantly on hill-tops in Mangwendi's and Makoni's country. We had heard reports of the walls at Chipunza's, in Makoni's country, and were told that we should find some ancient remains there, but all that we found were modern. There were, however, some tall monoliths erected, and we hoped we had found some trace of the old worship of standing stones which was practised at Zimbabwe. They would give us no information regarding these stones; but I was determined I would make them speak, and proceeded to pull one down, when they begged me to stop, and explained that it was set over the tomb of a chief.

The quartz reefs along the edges of the high plateau towards the Zambesi and the Sofala coast have been most extensively mined, and the workings have been made with great skill and carried to a considerable depth. I do not think that we are justified in assuming that these mines were made by the old temple builders, for the temples are never built on the quartz formation, but always on the granite; and although they sometimes stand within a few miles of the quartz formation, yet they are least numerous where the quartz has been most worked. Zimbabwe itself is within four miles of the quartz; but although the formation here is probably richer in gold than in most parts, it has hardly been worked at all. The people who built Zimbabwe probably came to the country for gold, and they probably obtained it, as the Kaffirs obtain it now, from the river sands, and did not mine the reefs. The mines were probably made by the Kaffirs in the middle ages under Arab direction, when the Arabs were trading on the coast; and from what the early Portuguese historians tell us, we may, I think, assume that gold-mining continued until the arrival of their countrymen in the eighteenth century, when the Monomotapa empire had begun to break up. Some people in this country have asked me if the old people did not exhaust the reefs which they worked, and I made quite sure that they did not; for

I have been at the bottom of old workings which had been cleared out, and seen the reef continuing and carrying visible gold, and I obtained samples of the quartz.

I am sorry that I have not had time to tell you more of the people, but I have endeavoured to tell you something of Mashonaland as it was up to the time of our visit. Now it is a somewhat different country. The country was little known then, and many of the people had never seen a horse, and admired (what they called) the antelopes which we rode. Good waggon roads now traverse the country, and there are regular mail coaches and 900 miles of telegraph, and there will, in three or four months, be a railway. Considerable townships have sprung up, around which land has attained considerable value, and two of these townships have newspapers. The mining prospectors are everywhere, and working to good purpose. In the 200 miles of what was most savage country between Tuli and Victoria, and where many people nearly perished from starvation, there are now ten hotels. If it were possible for Sinbad the Sailor to revisit this scene of his exploits, he would not know the country, and, moreover, he would run the risk of having many of his best tales contradicted by telegraph.

IV.—*Recent Developments of the Hamilton Coalfield.* By Robert Thomas Moore, B.Sc., Civil and Mining Engineer.

[Read before the Society, 25th January, 1893.]

Plates II. and III.

In 1845 the total quantity of coal raised in Scotland was estimated at four million tons, of which one million tons were probably raised in Lanarkshire. In 1891 the quantity raised in Scotland was over twenty-five million tons, of which fourteen million tons were raised in the county of Lanark.

The prosperity of the city of Glasgow and of the many industries in its neighbourhood depends so much on the supply of coal from the Lanarkshire coalfield that any information regarding it cannot fail to be of interest to the members of this Society, and I propose to make a few remarks to you on the recent development of the Hamilton coalfield, from which a large proportion of the supply now comes, and then to give a few remarks as to the duration of the coal in Lanarkshire.

Description of Field.

What may be called the Hamilton coalfield is that portion of Lanarkshire traversed by the Caledonian Railway from Cambuslang, by Newton and Hamilton, to Larkhall, and extending for a mile on either side of it. I propose to trace the development of the collieries upon this field for the last thirty years, and show its importance in the increased supply which is now obtained from the county. The other portions of the Lanarkshire coalfield will only be referred to in so far as they illustrate the district in question. I shall enter into as few technicalities as possible, and simply describe generally what has been done to produce the considerable addition to the output of coal which those operations have brought about.

The coals in this portion of the coalfield are wholly overlaid by red sandstones. At one time it was assumed that these were the old red sandstones, and that, consequently, there was no coal below them. In 1845 their true position was well ascertained,

and it was known that the coals lay beneath. In that year a clear description of the coalfield was given in evidence before Parliament in connection with the Clydesdale Railway Bill, and it was noted that the deepest point was at Bothwell. It was not thought, however, that it would be so soon in request, for it was added that at that depth it was not likely to be worked in the meantime, though it would be available for future generations.

In Scotland seams of coal are found (1) in the coal measures; (2) in the carboniferous limestone measures; and (3) in the calciferous sandstone measures.*

In the first of these—the coal measures—are found the best seams of coal, the blackband and slatyband ironstones, and also the famous Boghead gas coal. In the second—the carboniferous limestone—are found many valuable seams of free coal and cannel, and blackband and clayband ironstone. In the third—the calciferous sandstones—are found only one seam of coal of importance (the Houston coal) and the various seams of oil shale, from which oil is extracted at West Calder, Pentland, and Burntisland.

The coal measures are fully as well developed in Lanarkshire as in any other county in Scotland. They are at their greatest thickness at Hallside Colliery, Newton, where the first seam of coal is at the deepest point at a depth of 206 fathoms from the surface and 1,056 feet below sea level.

In Lanarkshire the seams of coal in the coal measures are locally divided into two groups:—(1) the upper coals, containing the seams of coals down to and including the splint and virgin coals; and (2) the lower coals, containing those lying below the virgin.

In my remarks upon the Hamilton coalfield I shall only deal with the upper group, as those are the seams upon which the collieries have been founded. Where these seams are fully developed, they contain 30 feet of coal, in seams above 2 feet in thickness, but the seams are at no point all at their maximum thickness, and the average thickness of coal in them in the district cannot be taken at more than 22 feet.

On the accompanying map (Plate I.) I have shaded the area of ground in Lanarkshire containing the splint coal and also the area containing ell coal, the second of the series. The area containing

* There are also some seams worked in the lias formation at Brora, in Sutherlandshire, but these are of little importance.

splint coal is 80 square miles, while that containing ell coal is 66 square miles. To avoid confusion, I have not given the outcrops of intervening seams. As far as the Hamilton field is concerned, this is of no importance, as it contains the position of all the seams. Although the position of the various seams always exists, yet there is great variation in their thickness and quality at various points. I have given a section taking in the Hamilton field. It begins at Glasgow, and follows the Hamilton branch of the Caledonian Railway to Netherburn, showing the depth to and the thickness of the various seams of coal there.

I shall now describe them, noting the variation in the thickness and quality of each separate seam. (See Sections on Plate III.)

THE UPPER COAL.

This is the first workable seam lying below the red sandstone. At Govan, Stonelaw, and Eastfield Collieries, it is a first-class house coal, 4 to 4½ feet thick. At Cambuslang it is 2½ to 3 feet thick, but not of better quality than the other seams. At Greenfield it is so thin as to be unworkable. At Hamilton it is still unworkable, and continues so to Larkhall. It reappears at Skellyton, where it varies from 2 to 4 feet in thickness, but is of no better quality than the other seams.

THE ELL COAL.

This is the most important seam in the district, but it, too, has great fluctuations, both in quality and thickness. At Govan Colliery, Stonelaw, Eastfield, and Cambuslang, it is of second-class quality, and 4 feet thick. At Newton it continues about this thickness and quality, but at Greenfield it has a thickness of 7 feet, and the quality is much improved. At Hamilton it is 7 feet thick, and is an exceptionally fine house coal. From Hamilton up to Cornsilloch the thickness is sometimes as great as 10 feet, although the upper portion is not of so good a quality, and not more than 6 feet of it are worked.

PYOTSHAW COAL.

At Govan, Stonelaw, and Eastfield, there is no trace of this seam, but at Cambuslang it is found from 2½ to 4 feet in thickness, and it continues about 4 feet thick on to Hamilton. Above Hamilton it gradually gets thinner, till at Bog it is

2 feet 4 inches, and unworkable. The quality does not vary much, and it is never a first-class coal. It is a splinty coal, and is used for furnaces.

Main Coal.

The main coal is a seam of ordinary coal, varying less in quality and thickness than any of the other seams, and usually about 4 feet in thickness. At Govan, Stonelaw, and Eastfield, it varies from 4 to 5 feet in thickness. At Cambuslang it is 4 feet; at Newton it is about 3½ feet; at Hamilton it is 4 feet; and continues at this latter thickness up the valley as far as the section extends.

A peculiarity in the main and pyotshaw seams is that the intervening strata vary greatly. Sometimes the seams are close together, and at other times they are separated by as much as 30 feet.

It has been suggested that the seam known as the main coal at Govan Colliery and Eastfield is the pyotshaw and main coal combined, but a comparison of the main coal at Govan and Hamilton shows that this is not the case. The "partings" in both seams are the same, and a bed of cannel coal, which is sometimes found on the top of the seam at Govan, is found in the same position in the main coal at Hamilton.

The Humph Coal.

This is a seam varying from 2 to 3 feet in thickness, and of no great quality. It has been extensively worked about Govan, Stonelaw, and Eastfield, but not in the Hamilton coalfield.

The Splint Coal.

This is the most persistent of all the seams, although it varies fully as much in composition and thickness as any of the others. It consists of a portion of hard splinty coal, with portions of free or cubical coal above and below it. Occasionally a layer of cannel or gas coal comes in between the splint and free coal, increasing the thickness of the seam. At Govan, Stonelaw, and Eastfield, and as far as Cambuslang, it is a seam about 3 feet in thickness. At Hamilton sometimes a layer of cannel comes in, and the seam is thicker.

The Virgin Coal.

This is a seam of coal from 2 to 3 feet in thickness, which is sometimes close to the splint coal, and both coals are worked as one seam.

At Govan it lies 12 feet below the splint, and is a good workable seam of 3 feet. At Stonelaw and Eastfield it is within 3 feet of the splint coal, but under 2 feet in thickness, and unworkable. It continues about this thickness till near Hamilton, where it is 3 feet thick and close to the splint, the two seams being together, and forming a working 7 feet thick. The two seams are together above Hamilton, the thickness being about 6 feet.

Instead of putting the thickness of each seam at each of the collieries, I have noted at four different points the total thickness of coal in the workable seams. I have also in the section (Plate III.) given details of the various seams at the points noted. From these it will be seen that, although the total thickness of workable coal does not vary very much, the thicknesses of the seams which go to make up these total thicknesses vary to a considerable extent.

Development of Field.

The greatest development of the Hamilton coalfield took place about two periods. The first of these was about 1860, when most of the collieries eastwards along the Lesmahagow branch were opened up; and the second, following the "good times" of 1870, when the pits about Hamilton, and from there down to Cambuslang, were opened up.

There may even be said to be a third period—that following the "good times" of 1890—but as there were only few fields left untaken, this is of limited extent, and consists of the opening out of some four or five collieries.

Now the whole field in question is leased and operated upon.

In 1856 the output from the collieries in the district from Glasgow to Skellyton would probably be ... 1,200,000 tons.

In 1860 it would be	... ...	1,200,000 ,,
In 1865 ,,	... .	1,200,000 ,,
In 1870 ,,	... ...	1,300,000 ,,
In 1875 ,,	... ...	3,000,000 ,,
In 1880 ,,	... ...	4,230,000 ,,
In 1885 ,,	... ...	6,100,000 ,,
In 1890 ,,	... ...	7,500,000 ,,

When the new collieries which have been started since 1890 are fully developed, the annual output will probably be 8,000,000 tons.

Improved Arrangements.

In the fittings commenced after 1870, the first workable seam—the ell coal—being at a depth of from 100 to 200 fathoms, a large amount of capital had to be expended, and it was necessary to raise large outputs in order to make the collieries profitable. To do this, the most improved arrangements had to be adopted. Instead of sinking shafts of the then usual size of 16 feet long and 5 feet wide, some of them were made 24 feet long and 8 feet wide.

In some cases heavy pumping engines were fitted up; but although in sinking some of the pits a considerable quantity of water was met with, the field is now so well drained that there is little water for each colliery.

The winding engines are wholly of the horizontal type, and direct-acting, with double cylinders. They are from 80 horse-power to 250 horse-power.

The pitheads and railway siding arrangements are all made on a larger scale than formerly.

As a rule, the seams lie flat, the rate of dip varying from 1 in 10 to 1 in 20, although in some exceptional cases, as in the Cambuslang Coal Company's Gilbertfield Collieries, they are as steep as 1 in 2. Generally the field is free from "troubles." These conditions enable the most improved systems of haulage to be freely adopted.

The mode of working is almost wholly by "stoop-and-room," the stoops being left from 30 to 50 yards square, regardless of the depth, and the rooms or galleries 10 to 12 feet wide. These stoops are worked systematically away after a certain area has been blocked out, with the result that about 95 per cent. of the whole coal is got. The former practice was to leave pillars of a smaller size, depending on the depth of the seam from the surface. Generally one-third of the coal was left in pillars, and, as the roof fell in the rooms, the expense of getting them out was so great that it did not pay, and one-third of the seam was lost. The leaving of large pillars was introduced by the late Mr. M'Creath, who, about 1862, introduced a clause in the Hamilton leases that no pillar was to be left of a less area than 400 square yards. This

was objected to at first by the coalmasters, but gradually, as the evident benefit of the change became apparent, every-one adopted it, and now, instead of 400 square yards, the pillars are frequently 2,000 square yards in area. There is no general rule as to which seam is first worked, but, as far as possible, the stoops are worked away in one seam in an assigned area before any working is made in the seams above or below it, as it is found that the subsidence of the strata when the pillars are removed affects the roads in a seam above or below, although there may be 20 fathoms of strata between them.

The amount of subsidence of the surface caused by the extraction of the coal is found to be 75 per cent of the thickness of coal taken out. Thus, when a seam of coal 4 feet thick is exhausted, the surface subsides 3 feet. The "draw" or distance at which the surface is affected beyond the workings is about one-third of the depth from the surface.

Before the opening of these fields the tubs in which the coals were drawn from the faces held about 7 cwts. In the new collieries they are made to hold about 14 cwts., and in some instances 20 cwts. They run on bridge rails weighing from 15 to 25 lbs. per yard. Generally they are drawn singly from the faces for 100 to 200 yards by men, then they are marshalled into trains, and drawn by horses or rope haulages to the shafts. In some instances they are drawn from the faces to the first station by horses or ponies, and no men are employed.

Hitherto coal-cutting machines have been seldom used, it being held that in a 4-feet seam there is no saving. At Hamilton Palace Colliery a heading machine, which cuts a round tunnel in the coal, has been worked for some years. This enables a passage to be driven more quickly than can be done by hand labour, and so opens out the workings more speedily.

Electricity has been adopted to a very limited extent. An electric pump is in operation at one colliery, and it is proposed to adopt it for haulage at Earnock Colliery, where it has been used for lighting, both at the surface and at the pit bottom, for over ten years.

All the seams in these collieries give off fire-damp to a much greater extent than other portions of the Lanarkshire field, as the unfortunate explosions at Blantyre and Udston bring vividly to our minds, and the result has been to call for much larger arrangements for ventilation than were formerly necessary.

Large ventilating fans are in operation at all of the collieries. One of these, at Blantyre, is 45 feet in diameter, and is worked by an engine 100 horse power, distributing 250,000 cubic feet of air through the working at a pressure of 2 inches of water. It may give an idea of this quantity to say that it is equal to a current of 120 miles an hour, passing through a doorway 8 feet high and 3 feet wide.

Many of the collieries are worked solely with safety lamps, and in all of them such lamps are more or less employed.

Previous to 1860 the tubs of coal, as they were raised to the surface, were emptied over a screen, and the lumps rolled into one waggon while the dross fell into another. Now it is very different: the coal is emptied from the tubs on a shaking screen, which effectually separates the large coal from the dross. After passing over the screen, the coals land on a moving picking table, which carries them slowly along for 30 or 40 feet to the waggon. Men and boys, and, in some cases, women, stand on each side of the picking table and pick out the stones (chipping off with hammers the pieces which adhere to the coal), or separate the different qualities of coal before they reach the waggon. The dross which passes through the screen falls into a pit, from whence it is raised by machinery, and passed over screens, so as to be assorted into different sizes of "nuts," "beans," "peas," &c. These small sorts are washed by being agitated with water in tanks, where the refuse, in consequence of its greater specific gravity, falls to the bottom, and the clean coal is run over into separate waggons. In this way the coal is subdivided into different sizes, which suit different markets, and a better average price is got.

The result of all this cleaning and subdivision is to necessitate a large manufactory on the surface, very different from the establishments existing at the older collieries.

The railway waggons now hold 8 to 10 tons instead of 5 tons in 1870; and 3 tons, which was the load when the Caledonian Railway was opened in 1848.

At many of these collieries 100,000 tons are raised from one shaft in a year, and in one case as much as 200,000 tons. The outputs are still, however, far short of those obtained from many English pits.

A characteristic of Scottish mining which has been carried into the Hamilton district is the relatively small area of coal worked by a pair of pits. In England a pair of pits frequently work the

coal from two or three thousand acres, the workings extending sometimes miles from the pit bottom. In the Hamilton district few of the leaseholds are larger than 300 acres. In one instance a pair of pits have been sunk 150 fathoms for a field of 60 acres.

There is much to be said for and against such a custom. It certainly ensures a larger annual output from a given area, but it tends to the earlier exhaustion of the field. Where the field is so thoroughly opened up with railways as the Hamilton field is, the cost of haulage is reduced by the existing system, and I think there is no doubt the total cost of raising is cheaper.

Such a state of affairs was never contemplated thirty years ago; but so great has been the advance in the progress of mining knowledge in the laying out of mines, and in the employment of machinery and appliances, that the coal in these deep pits in the Hamilton coalfield can be raised as cheaply as in those older collieries more favourably situated. Indeed, I am inclined to think that coals are raised as cheaply in the Hamilton district as in any part of the United Kingdom.

Most of the collieries are owned by limited liability companies, and while some of them have occasionally paid large dividends, the average return on the money invested has been far short of the 10 per cent. to which capital invested in a hazardous investment is fairly entitled.

Safety and Comfort of Workmen.

Unfortunately, explosions causing large loss of life have occurred, and probably will occur, in spite of all precautions. These bulk largely in the public mind, though the largest number of deaths occurs from accidents where only one or two are killed.

Much, however, has been done to increase the safety and comfort of the miners and those employed underground and on the surface. For the five years ending 1855 there was one fatal accident for every 294 persons employed underground in the United Kingdom; for the five years ending 1860 there was one fatal accident for every 342 persons employed; for the twelve years ending 1872 there was one fatal accident for every 400 persons employed; for the fifteen years ending 1887 there was one fatal accident for every 594 persons employed; and for 1891 there

was one fatal accident for every 712 persons employed—a very satisfactory improvement.

There is no doubt that mining is and always will be a hazardous employment, but this rate compares favourably with many other trades which are not generally considered so hazardous. It has been said that the safest place in the world is a railway train; but while this may be the case as regards the passengers, a collier has as safe an occupation as a railway servant, where the death-rate for 1891 was one for every 695 persons employed.

Underground, the workman has many comforts in a Hamilton colliery. His working place is roomy, well ventilated, warm, and dry. He is not exposed to the weather like an agricultural labourer, and his wages are much higher. He enjoys an independence that is not enjoyed by a mechanic in taking a day's holiday when he has a mind, and, on the whole, a collier's lot is a much happier one than that of many other classes of skilled or unskilled workmen. All the pit-heads and surface arrangements are covered in so that the workmen are protected from the weather. It is now thoroughly recognised that it pays to make a man comfortable when he is at his work.

Duration of Lanarkshire Coalfield.

I have estimated that the quantity of workable coals in Lanarkshire in the upper group of coals—those above the splint coal—may be 933 millions of tons. At present probably 11 out of the 14 million tons come from these seams. It may be well to see how long this will last at this rate of output.

Up to 1872 there were no reliable data from which to make up the output, and, therefore, we can only assume what it was up to that time. After that date each coalmaster was bound to make an annual return of output, and the exact figures can be got.

In 1845 a very careful observer, the late Mr. M'Creath, estimated the annual output of Lanarkshire at one million tons. Probably at the beginning of the present century it was not 500,000 tons a year, but it might be safe to estimate the whole coal worked from the field up to 1845 at 50 millions of tons; and, allowing for losses through coal left in pillars and dross left in the workings, this would probably represent 100 millions of tons. It will be necessary to make similar allowances for coal left in pillars and dross up to 1873.

The quantity of coal worked up to the present date might be made up as follows:—

Prior to 1845, ...	100	million	tons.
From 1845 to 1860, ...	150	"	"
" 1860 to 1873, ...	196	"	"
" 1873 to 1892, ...	222	"	"
Total quantity worked, ...	668*	"	"
Estimated total quantity, ...	933	"	"
Leaves unworked, ...	265	"	"

As I have already said, all the pits necessary for exhausting these seams have been sunk, and the only means of increasing the annual output will be by the introduction of improved modes of working, whereby the output from each pit may be increased. But as the older collieries will be getting exhausted in these seams, it will take any increased output from this source to maintain the present output of 11 million tons, and I do not think this can be increased. At this rate the field will last 24 years. This will finish the cheaply worked coals of Lanarkshire. All the collieries will not be exhausted at once; a few which have large fields may continue to work these seams beyond this time; but most of the others will be exhausted before it.

The continuance of the supply after this, and any increase of the present output, must come from the lower group of coals, those below the splint. These are at present being worked in Lanarkshire to the extent of about 2½ million tons, and they extend beyond the area of splint coal shown on the map.

They are being worked at Shotts and Bathgate, at Slamannan, at Airdrie, at Wishaw, at Larkhall, at Lesmahagow, at Carluke, and at Shettleston. At Dalmarnock, near Glasgow, no workable seam was got in a bore put down 80 fathoms below the splint coal; and at Hamilton Farm, near Cambuslang, only one seam over 2 feet in thickness was got in a bore of the same depth.

It is difficult to estimate what their thickness may be in the Clydesdale field. Taking all the circumstances into account, I estimate that 1,000 millions of tons would be got from the coals of this group in Lanarkshire.

* Some of this output would be worked from the lower group, but the quantity is so small that it is not necessary to separate it.

The lowest of these seams will be 370 fathoms from the surface at Newton. These seams will be worked in the Hamilton district as the upper seams are becoming exhausted, and so as to keep up the output from each colliery. They will be more expensive to work, and a less output will be maintained from them.

With this in view, I think the annual output from Lanarkshire will not increase more than 2 per cent. per annum for the next 20 years; and at this rate the whole coal in the coal measures of this field will be exhausted in the next 60 years.

The only seams remaining are those which may be got in the carboniferous limestone series. These coals extend over a larger area than the coals in the coal measures. They are at present being worked at Bo'ness, at Bathgate, at Wilsontown, at Lesmahagow, at Kilbride, at Knightswood and Possil, and at Kilsyth. At Hamilton the depth to the first of these coals would be 450 fathoms, and to the lowest 600 to 700 fathoms.

So far as our present information goes, it is rather against coals of value being found in this series below the upper measures in the Clydesdale field, but it is very desirable that they should be proved by boring, for it is evident that before long—for 60 years is not a long time—we shall have to be looking out for a fresh supply of coals for Glasgow.

Waste of Coal.

I have pointed out that by improvements in working the loss of coal has been lessened until 95 per cent. of the whole seam is obtained. This does not leave much room for further saving, and it is evident that the producer is doing his part in the saving of coal fairly well.

The consumer, however, does not show so good a record. Many of the steam engines which are employed in our workshops and factories burn 10 lbs. of coal per horse power per hour, while the triple-expansion engines of our steamships burn only 1½ lbs.—that is to say, that for every 100 tons of coal burned there are 85 tons absolutely wasted. No doubt, so long as coal is cheap and plentiful this will go on, as it is expensive to alter existing plant, but the fact remains that we are actually throwing away fully 80 per cent. of the coal used in our factory and workshop engines.

Then many of our industrial processes are most wasteful of fuel, and our domestic fires also use much more coal than is necessary. It may be said that, with 60 years' supply in view, sufficient for

the day is the evil thereof, but it is well that the public should have the facts before them so that they may not plead ignorance.

The greater the amount of coal consumed, the greater the amount of fogs, and if the same amount of work could be got out of 1½ million tons instead of 10 millions, the result could not be otherwise than beneficial.

I have often thought that at some future time we shall give up to a large extent the use of coal in our large cities for driving small engines, and either have large gas producers at our coal fields and bring down the gas in pipes—as they are now doing in America—to drive gas engines, or erect large and economical engines at central stations, and distribute the power in the form of electricity, hydraulic pressure, or in some other similar way. The erection of hydraulic power stations, like those in London and those being established in Glasgow; of compressed air systems, as at Birmingham; and of electric power stations, where economical engines and boilers are erected to supply power to small and intermittently-working engines, are all steps in this direction. In whatever way it is to be done it is evident that a large field exists for the saving of coal.

V.—*On a New System of Firing Pottery-Ware by the Use of Gaseous Fuel.* By W. F. Murray, Caledonian Pottery, Rutherglen.

[Read before the Society, 19th April, 1893.]

Plate IV.

In all branches of industry the need of more economical methods of production has in these days become very urgent. The keenness of competition, the difficulty of controlling labour, the extravagant use of fuel, and other minor causes have combined to produce in some trades, if not the disappearance of, at least a reduction in, profit that is disquieting. With a population rapidly increasing, it is unlikely that competition will be mitigated; with labour, intoxicated by a sense of newly-discovered power, it is improbable that the control of it will become more easy; and it is mainly in the economical use of our supplies, especially of fuel, that the chief hope of restoring prosperity to our manufactures lies.

The extravagant use of coal is a reproach to all the manufacturers of this country, and none of them are more guilty of this extravagance than potters. In the iron and steel industries great economies have been effected in the use of fuel, and consequently the iron industries have greatly developed, and the steel industries have been created by the adoption of scientific and economical methods of obtaining and applying heat.

These improved methods are largely due to the use of fuel in the gaseous, instead of in the solid form. Similar, but greater, economies await the pottery trade, and they are to be reached by the same paths as have conducted metal workers to comparative prosperity. In the pottery trades the economies that can be effected by the employment of the fuel in the right form and in a scientific manner are much greater than are possible in the iron and steel trades, because, while in the latter each furnace works independently of every other, in the former the kilns can be worked combined in such a way that the waste heat of a kiln that is being fired need not be permitted to escape until it has been used to heat partially one or more kilns that are about to be fired.

For a great many years persevering efforts have been made at the Caledonian Pottery, Rutherglen, to give practical effect to these ideas, and, through many failures, complete success has at last been attained. The object of this paper is to set before you a description of the method of firing pottery-ware by gas that has been found successful. The system of firing introduced at Rutherglen embodies these six principles :—

I. The use of fuel in the gaseous form.
II. The use of heat hitherto wasted.
III. The equal distribution of the heat generated.
IV. The mingling of gas and air in any desired proportions.
V. The gradual and progressive heating from zero to any temperature wanted.
VI. The gradual and progressive cooling back to zero again.

The manner in which these six ideas are applied to the firing of earthenware, and the remarkable economies effected by their application, will, I hope, be made plain by an examination of the sketches on the wall (see Plate IV.), and by the comparison which will be instituted between the working of coal-fired kilns and those that are gas-fired.

Referring to the drawings of the gas kilns—

A the main gas flue.
B the branch flue.
C the gas valve.
D the annular gas flue under the kiln bottom, communicating by opening in the roof of the flue with the combustion chamber G.
E horizontal air flue under kiln bottom, communicating with
G combustion chamber, where hot gas and hot air meet and mixture is ignited.
H damper for light, and for allowing, when necessary, deleterious gas to escape.
I exit holes in kiln floor, communicating with
J horizontal exit flues, leading into
K the central well, which is tapped and drained by
L a flue leading to next kiln of the series, or to
M the branch flue, communicating with
N the main flue, leading to
O the chimney, which ought to be at least 7 feet square by 120 feet high.
P damper, put down when waste heat is passed to the next kiln in succession instead of to the chimney.
Q damper, put down when waste heat is passed to the chimney instead of to the next kiln in succession.

Alongside of the drawings of the gas kilns is shown a sketch of the ordinary coal-fired kiln, in which nine fires are kindled in the furnaces A, placed at equal distances round its circumference. From these the heat takes the shortest and easiest way, partly *via* the bags B, and partly *via* the flues C and D, to the opening E in the crown, through which it escapes, generally in a smoky stream to pollute the atmosphere, after having done, like too many of us, the minimum of work at the maximum of cost. It would be difficult to contrive a method more wasteful and inefficient than this.

The only practical alteration made on this method—some potters say it is no improvement—is what is known as down-draught firing. By this method the heat is generated in the same way as has just been described, in mouths A, and then it ascends straight up out of the bags B, but, the opening in the crown being closed, it descends again, and is drawn off at the bottom either into uptakes formed in the wall of the kiln, or by an underground flue, to an independent chimney. This latter system of firing, if it requires a reduced amount of coal, has been found to involve a greater loss of seggars and ware than the common up-draught method.

If the waste heat of even a coal kiln could be transferred to another kiln, and there used, almost the same economy in the weight of coal might be effected as that which is secured in gas firing. But waste heat cannot be transferred from one coal-fired kiln to another, because the nine mouths of the firing kiln, and the same number in the receiving kiln, constitute, with their ashpits, eighteen huge leaks, by which such immense volumes of cold air are admitted that draught is killed, and the transfer of heat is impossible. Let it be remembered that the power of a chimney to draw, depends mainly upon the difference in the temperature of the column of hot air ascending within the chimney and the temperature of the outside atmosphere, and that the admission of cold air into a chimney injures the draught: a small amount will impair, and a large quantity will destroy it.

That considerable chimney power is needed to supply draught for, say, two down-draught kilns will be manifest when it is considered that the heat entering a kiln at the bottom naturally rises into the crown, and wants to stay there. That tendency has to be overcome by the greater power of the chimney; and when there are two kilns in combination with one another, the heat in

which naturally flies to their respective crowns, the chimney has not only to draw the heat and gases downwards out of the two crowns, but has to draw it, sometimes by devious flues, for a considerable distance, to the bottom of the chimney.

That is a hard task, even when, as in the gas kilns, there are no openings into them permitting cold air to enter their interiors; but it is a task entirely beyond the power of a chimney when, as in coal kilns, there are in each of them nine mouths, with their ashpits, forming eighteen huge gaps, through which cold air greedily rushes into the kilns. At Rutherglen, a few years ago, three coal kilns were connected with one another, and with a chimney 100 feet high. The attempt was made to transfer the waste heat of one kiln to another, in order partially to heat it. But, because of the numerous leakages of cold air both into the firing and into the receiving kiln, draught could not be obtained, and the experiment was a total failure. It may, therefore, be pronounced practically impossible in coal kilns to draw the waste heat of one kiln through a second one, much less through a third; and, accordingly, recuperative or regenerative firing cannot be accomplished in them. But what is impossible in coal kilns is perfectly easy on the Rutherglen gas-firing system.

Into the gas kilns there is no admission of cold air, or even of cold gas, for all the air and all the gas reach the combustion chambers, where they meet and ignite, by way of heated flues, within the kiln itself, and these flues are inaccessible to cold air. When the door of a gas kiln is built up, neither the interior of the kiln that is firing nor the interiors of the kilns receiving its waste heat can be reached otherwise than by highly-heated flues. There is no leakage of cold air into any of these kilns; the chimney draught is unreduced from that cause, and thus the chimney is able to act through several kilns, if they be gas ones; and only through one kiln, if it be a coal one. Thus, so far as the writer knows, it is gas kilns only that are capable of effecting the economy due to the useful employment of transferred heat; and as heat in coal kilns cannot be transferred, it must, of necessity, be wasted.

To compel waste heat from a firing kiln to enter another one, for the purpose of imparting to it a preliminary heat, some persons have advocated the use of a blast. This acts by pushing the heat from behind, instead of pulling it from before, as a chimney would do. But however suitable such a process may be for melting metals

where great local intensity of heat is required, it is quite unsuitable for use in a pottery kiln where equal diffusion of the heat is demanded.

These observations have dealt with the first two of the six ideas proposed for consideration, and your attention is now asked to the third point—namely, the equal diffusion of the heat generated. In this particular the coal and the gas kilns are more nearly equal than in any other respect, but even here the gas-produced heat is much more easy to control and direct than is the coal heat. In all kilns, whether fired by coal or gas, the tendency of the heat is upwards, and, by a proper application of chimney power, the heat can be drawn downwards from the crown to, or towards, any part of the kiln bottom where it is wanted. But, for the reasons already given, the power of a chimney is less effective in coal kilns than in gas kilns. In the latter, with the utmost ease, the heat is drawn from the crown and distributed over the area of the kiln, and it is directed to the point where it is wanted and to the extent to which it is needed. For example, it was recently found at Rutherglen that between two of the combustion chambers in one of the gas kilns, and on the kiln bottom, there had been too little heat to melt the glaze properly. At this point an opening about two inches square was made through the kiln floor into one of the exit flues. On the next firing it was found that the spot which had been short fired was well fired. The small hole that had been made had drawn the flame towards it, and that immediately corrected the defect.

The mingling of gas and air in any desired proportions is the fourth point upon which I desire to compare the coal and the gas-fired kilns. The two requisites for the production of the flame and heat are (1st) inflammable gas, and (2nd) air to support its combustion. If the supply of either the gas or the air is incapable of being controlled with some approach to precision, it is impossible to avoid variations in the mixture formed by them. If there be too much gas, the flame will be smoky and dirty; if there be too much air, the flame may be smokeless, but the excess of air will reduce the heat. In coal kilns both smoky and smokeless flames occur, and they usually alternate one with the other. When the nine furnaces in a kiln are charged with coal, the inflammable gases are disengaged freely, and usually dense volumes of smoke issue from the kiln chimney. This smoke represents wasted fuel. As the fires get spent, the proportion

of inflammable gases diminishes, while the amount of air entering the furnaces remains, roughly speaking, constant. Accordingly the smoke diminishes, and at this stage finally disappears, but only to reappear when the furnaces are fired again.

In coal-fired kilns the proportions of gas and air are in a continuing state of alteration, and at every firing there are in succession an excess, an equality, and a deficiency of inflammable gases, according to the stages which the furnaces have reached. In the gas kilns, however, it is easy to control and adjust the proportions both of gas and of air. Both reach the point of combustion by way of flues. Each is allowed to escape from its flue through openings which can be adjusted with the utmost nicety; and because the proportions of gas and of air can be so accurately adjusted, a flame of any required quality can be produced.

Let us again refer to the sketches. At each kiln there is a gas valve, C, which regulates the supply of gas for the use of the kiln in general, and this supply is admitted into the annular flue D, under the kiln bottom. Surmounting this flue are the nine combustion chambers, G, and an opening in the roof of the flue, which is the floor of the combustion chamber, admits gas into the latter. The exact quantity of gas admitted into each combustion chamber is regulated by opening or closing, by means of a sliding fire-clay cover, the opening between the gas flue and the combustion chamber. In a similar manner, the inlet of air is controlled, and the air and the gas can thus be supplied at any part of the kiln, and in any required proportions. It is superfluous to say that no such precision is possible in coal kilns.

My fifth point is the gradual and progressive heating from zero to any temperature wanted. Assume that three kilns—the usual number—are being heated simultaneously (see Plate IV.); that in the first, gas and air are meeting, burning, and are bringing the kiln to a high heat; that the second is heating moderately; and that the third is being gently heated. Each of these three is in a different stage of heating, and there are three distinct stages, each lasting from twelve to fourteen hours. No. 3 is at the earliest stage, and is receiving what may be called the preliminary or drying warmth, at the conclusion of which only a heat which the hand could almost bear is reached. At the same time No. 2 is receiving what may be called a medium heat, and at the conclusion of that stage has reached a full red. Along with these, No. 1, in which the heat passing through Nos. 2 and 3

originates, is receiving full fire, and at the conclusion of this, the final stage, the heat is almost white. When No. 1 is finished, the gas is turned off there, and at the same time it is turned on to No. 2, which then becomes the firing kiln in turn, and then the next two after it are receiving respectively, the medium and the preliminary heat. The heating of each kiln begins at zero, and by each of these twelve- to fourteen- hour stages, progresses and progresses steadily, with no retrogressions, till the requisite temperature is reached. Coal kilns are, on the other hand, liable to a reduction of temperature each time the furnace doors are opened.

When a coal kiln is fired, each of its nine furnace mouths is thrown open, and there is such a rush of cold air straight into and through the kiln that it is suddenly and violently cooled. On shutting the doors after the furnaces have been charged, there is as sudden and violent an increase of temperature. Each time the furnaces are opened, charged, and shut again, there are the same violent alternations of temperature, to the great destruction of seggars, of ware, and of the structure of the kiln itself. And since a coal kiln fires for about 28 hours, and each of its nine furnaces is "coaled" about once every 40 minutes, the doors are thrown open 370 to 400 times every firing; and every time a door is opened the effect of previous heating is to some extent neutralised. It is manifest that in this particular the gas kiln is strikingly superior to the coal kiln.

The sixth and last point—which is, the gradual and progressive cooling back to zero again—may be dismissed in a very few words. This is another particular in which the gas kiln and the coal kiln are not very materially different, but it is at all times desirable that the cooling, like the heating, should be gentle and gradual. Treated thus, the structure of the kiln itself is less injured, and the contents of the kiln—seggars and goods—are delivered with extremely little breakage. Especially where large pieces of ware are fired, the importance of slow cooling, as well as of slow heating, cannot be over-estimated. As a crucial test, there were recently put into No. 2 gas kiln six 25 gallon acid receivers; these were not even protected by seggars, but were placed, exposed and bare, on the tops of the bungs. In a coal kiln it would have been considered a very good thing if four out of six had survived the firing; in the gas kiln, the whole six were whole, and without any flaw. Potters will tell you that such an

experience is unprecedented. In a coal kiln it is difficult to close tightly all the numerous and large communications between its interior and the open air; in a gas kiln the openings are so small and so few, that they can be closed as tightly and as rapidly as a bottle can be corked.

It remains to be said that, whereas coal kilns require to be fired with coal of superior quality, good gas for gas kilns can be made from cheap dross or slack, and very little even of that is needed. Whatever may be the dimensions of the kilns, if the gas system of firing them is substituted for coal firing, it will be found that the economy in fuel amounts to about 60 or 70 per cent. in weight, and 80 to 85 per cent. in value, and that the economy in seggars will be even more important.

Thus treated, the comparative cost of the two methods of firing 15-feet kilns for stoneware pottery has been found to be as follows:—

Coal.				Gas.			
8¼ tons coal, at 7s. 6d.,	£3	1	10	3½ tons dross, at 3s. 6d.,	£0	12	3
Seggars, 180 p. kiln, at 6d.,	4	10	0	40 Seggars, at 6d., ...	1	0	0
Tear and wear of kiln, each firing, - -	0	17	6	... ...	0	5	6
Cleaning kiln and removing rubbish, -	0	7	6	... ...	0	2	6
Breakage and damage to goods, - - -	1	0	0	... ...	0	5	0
Cost per burning for coal kiln, - -	£9	16	10	... ...	£2	5	3
Cost per burning for gas kiln, - -	2	5	3				
Difference per burning in favour of gas, -	£7	11	7				

Although some advantages might follow the adoption of the gas-firing system on a small scale, yet the full advantages cannot be realised unless a set or sets of kilns are kept going continuously.

The kilns have been carefully examined and reported on by Mr. R. R. Tatlock and Mr. F. J. Rowan, two of the best British authorities on fuel, gas, and furnaces. I have only seen the report in draft, but it confirms every statement made in this paper. These authorities point out that there is a sacrifice of economy in the first and in the last kiln of a series, and that there would be no such sacrifices were there a sufficient number of kilns to be kept going continuously.

Two important consequences may be expected to result from the adoption of such a system of gas firing as has been here described :—

I. That potters who used them would be in a position to undersell those who did not use them.

II. That it might be possible to plant potteries in great markets like London, because, from the very small consumption of coal necessary in gas firing, it would become more important to be near a market for the sale of goods with a minimum of carriage, rather than near a cheap coal supply and far from markets.

If the facts and figures given in this paper are even approximately accurate, and of their accuracy neither the writer nor Messrs. Tatlock and Rowan have any doubt, then it is plain that there is impending a revolution in the pottery trades.

This is an age of competition, and the manufacturer who holds back and refuses to adopt an improvement in production, demonstrated to be efficient and economical as this system of gas firing has been proved to be, will have about as much chance in the modern strife of business as one of Nelson's wooden ships would have against a modern ironclad.

VI.—*On the Elements of Profits.* By SHERIFF MARK DAVIDSON. *(A Communication from the Economic Science Section.)*

[Read before the Society, 22nd February, 1893.]

INTRODUCTION.

THE Royal Commission on Labour will possibly find that all struggles between Capital and Labour are of one kind and have one object. We are apt to overlook, owing to the many side issues raised in cases where employers and workmen disagree, the fact that every one of these trade disputes has regard to the distribution of a portion of a certain fund, the price of the product. Frequently the contention is, *ex facie*, one as to the length of time of employment, as in the railway strike in Scotland; less frequently we have the modern form of the "sympathetic" strike, where one combination comes to the aid of another without making any demands on its own behalf; and occasionally there are troubles arising from differences in regard to the rules of employment, as in the Cardiff dock labourers' case. But in every instance the battle is really fought over the fund referred to, that portion of the price of the product which is left over after the fixed charges of rent and interest are satisfied—what has been called by an eminent writer the "Profits and Wages Fund." It needs no penetration to observe that a reduced day's work without change in wages involves the employment of a larger number of workmen, and, therefore, the absorption by labour of a greater share of the fund; and the converse is equally true where an extension of hours is aimed at by the employers. The "sympathetic" strike occurs only where a particular body of labourers are in danger of failing in their endeavour either to obtain a larger share of the fund or to protect the share which they already have, and it is due to the belief that the moral effect of success or failure in one branch of trade will, in the long run, be of advantage or disadvantage to the claim of labourers in general to a greater participation in the fund. When there is a dispute about the

rules enforced in a certain employment, the workmen adopt their position because they feel that the regulations in question would weaken their combination in its work of obtaining as large a share of the fund as possible; and the employers stick to their rules, because they think that to yield would in the end handicap them in making their claim on the fund.

Duty of Royal Commission on Labour.—Analysis of Elements of Profits.

The most important duty imposed on the Commission is, therefore, that of inquiring (1) into the laws which govern the distribution of this fund, apart from combination on the part of either claimant; (2) how far these may be influenced by such combination, especially on the side of labour; and (3) how the results of the action of combinations may differ in different kinds of industry. This latter problem is of the highest moment, and if the Commission can give a clear deliverance on it, and if that deliverance can be made widely known, they will have conferred an inestimable benefit on the community. The confusion which exists in this matter is very great, and, without some authoritative exposition, seems to be irremediable. Such an ordinary phrase as this, "the wages of labour are paid out of the product," is enough to exemplify the looseness of thought and obscurity of expression which prevail in most circles when the wages question is discussed. What are we to say of the wages of dock labourers, or of seamen, whose work exhibits no tangible product? How do we account for the wages of cab-drivers, who have nothing to do, either directly or indirectly, with any product at all? If, indeed, it were fully understood that it is the price of the product out of which wages come, and that the word "product," to be used as a general term, must be in many individual instances metaphorical, the objectionable phrase might be allowed to pass; but it is not so understood. Again, it is a frequent contention (in some cases probably a sound one) that shorter daily or weekly periods of work are in reality more productive than unduly long stretches. But how can this axiom be applied to a railway servant, whose product (quantity of carriage performed) depends, not on himself at all, but on persons unconnected with him? Or to an assistant shopkeeper, whose eight hours' work can never equal his ten, unless for two hours in the day customers agree to refuse to come and buy?

These examples of inaccuracy I have given as instances of the vagueness with which the matters being investigated by the Commission are looked on and talked about even by people of an economic turn of mind. The brief analysis of the elements of profits which I have made (necessarily incomplete) is intended, not as the foundation for a scientific theory, but as a guide to thinking people, to point out to them the directions in which they may set their minds to achieve a solution of some of the difficulties of the wages question. When I use the ambiguous term, "solution," I do not, of course, wish to be understood to mean the final settlement of the antagonism between Capital and Labour; what I do mean is the scientific explanation of the phenomena of that antagonism, and the effects produced by certain specified causes. I am convinced that we are working in the dark at present, to a great extent, and we are so working, chiefly because we habitually regard labour (in the ordinary sense), capital, and employment, as things which are homogeneous; and, where we observe and admit of varieties in kinds of labour, or of capital, or of employment, we regard the variations as accidental, and use them habitually to defend special or unusual methods of treatment, instead of analysing them to see how far they are fundamental. Thus it is said of some particular kind of employment that it is safe to regulate it by law, because it is subject to no foreign competition; of some kind of capital, that it ought to be treated in a particular manner for revenue purposes, because its owners have a monopoly; of some kind of labour, that it is subject to none of the recognised laws of wages, because it is unproductive. But no categorical classification, even of the differences admitted by those who use phrases such as the foregoing, presents itself to the mind of the majority.

ANALYSIS OF WAGES.

At the risk of being tedious, I am moved to give yet one more example. Labour, in discussions of the question of wages, is generally understood to comprehend all unskilled work, all manual skilled work, a certain small but indefinite proportion of mental skilled work, and no more. Even by those who have more clearly-defined ideas of the limitations they allow themselves in the definition of labour, all work other than this is explained as being subject to some special rules, and is treated as if different in kind from labour proper. Yet Mr. Francis A. Walker, in his

admirable analysis of wages, adopts a limitation which seems to me to exclude from his theory not only almost the whole of mental labour, but a vast quantity of manual labour also, for he requires a material product out of which to pay wages. In general, we classify the work of a cab-driver and that of a weaver as labour of the same kind, when we are considering the rules which fix the wage of each; and we do not place a physician in the same category with them. Yet the cab-driver and the physician are much nearer to one another than either is to the weaver. Neither of the former can possibly claim a share in any product of their labour, for there is none; while the weaver can. The doctor and the cabman both receive their wages out of capital pre-accumulated; the weaver, according to the modern theory, is paid out of the result of his own labour. The first two are each of them individual workmen, doing their whole business in isolation; the weaver is part of a complicated system, in which many grades of labourers are employed, each one necessary to the others. Lastly, the earnings of the doctor and the cab-driver are fixed by law or custom, in so far as to be practically stereotyped; the weaver's wages are open to any temporary economic influence. In one point only do the weaver and the cabman coincide, as opposed to the medical man—they are paid by contract under a master, while he is not. In some towns, such as London, even in this matter the driver and the doctor are similar, and where the other practice prevails the difference is not so important as it at first sight appears. The ordinary classifications of labour appear to me as little scientific or instructive as Marx's famous division of work into that which counts and that which does not count.

Where the economic schemes of the distribution of wealth fail, it seems to me, is in their inability to explain existing phenomena. They divide the product of industry in various ways, while the old method is the simple three-fold distribution into rent, profits, and wages, which has recently been extended and diversified. We observe that there is an element of wages in what are commonly called profits, and we call it earnings of management, or reward for business ability; we set interest aside by itself, because it is not necessarily coincident with other profits; and we find an element of rent in the faculties of the skilled workman. These discoveries all show an advancement in the science; they are proof of the greater care with which the analysis of economic phenomena is being carried out. But they do not

yet afford us a set of rules by which we can say that the process of distribution is governed. They do not, for instance, give us any enlightenment as to the proportion of an employer's profits which form his wages for managing his business, nor do they explain in what way these wages which are paid by a man to himself can be subject to the laws which govern ordinary contract wages. They do not tell us how it comes that, in a particular trade, enormous fortunes are made by some individuals, while others of fair capacity struggle hard for a livelihood. They do not help the skilled labourer to discover how the value of the quasi-rent he receives is regulated, and by what methods it is to be increased.

While we have discarded some of the narrow views of the classical writers, shifted our standpoint till we have got a wider and fuller knowledge of our subject, we seem to have lost their strict scientific method, and forgotten that, when a problem like the labour question is put before us, we ought to be ready with a clear and distinct code of laws, in which we establish the sequence of cause and effect with scientific certainty. The old school settled this labour difficulty to their own satisfaction very briefly. Wages, they said, depend on the ratio of capital to population; $W = \frac{C}{P}$; add up capital and take a census, and, with a trifle of arithmetic, you have wages. Therefore, as only C and P are the elements of W, trades-unionism can do nothing to raise wages. We now see clearly that the above formula explains nothing; we know it to be founded on very misleading assumptions; and we do not regard any corollaries deduced from it as necessarily of any value. But though the reasoning was wrong, the method was right; and if we cannot now settle everything by the application of a single equation, we are none the less bound to attack the difficult and complicated problem before us with the determination to be not less exact and concise in our conclusions than the inventors of the wages fund doctrine. Unless we aim at the establishment of a system of economic laws which will be received and trusted by persons who are outside of our science—just as the laws of chemistry are trusted by those who are no chemists, and the signs of the sky by those who are no astronomers—we shall never be of real service in those social and political discussions in which economic science is peculiarly fitted to play a helpful part.

Value dependent on Utility and Scarcity.

It is no novel starting-point to begin with the axiom that value is dependent on utility and scarcity, which is merely a re-statement of the old law of Supply and Demand. It is not, however, necessary for my purpose to do more than call attention to the fact that, given utility whether great or small, it is only on account of scarcity that any article or service comes to have a value. Now, scarcity applies to the quantity of any thing which is not actually unlimited; it applies to the most common things in every-day life. Any thing that one desires and has not possesses scarcity to him; even where he wishes a loaf of bread which he can buy for threepence, it is his lack of bread that induces him to part with threepence to obtain it. It is well to observe that this power of scarcity to engender value is not to be found alone in our existing system of production and distribution; it is not necessarily connected even with private property. In a community in which Socialism was carried to its furthest limits, we should observe the same phenomenon. Suppose the State to hold all the land and all the materials of production, it is clear that labour of different kinds would have to be distributed among the citizens. Some labour of a pleasant description would be much sought after, and, as only a certain number could be employed in it, there would be a scarcity of this particular kind of employment. Consequently, those who desired to work after this fashion would offer to do a greater quantity of the favoured work than people were doing in other employments at the same rate of reward. The scarcity of the work would induce men to offer a higher labour-price for it.

Monopoly in Relation to Value.

And now we might find another term which will express what we mean as well as "scarcity," and which has the merit of being already in common use in political economy. Scarcity invariably implies Monopoly. We are accustomed to use this word in a restricted sense, in which we apply it to the possession of commodities of which the supply is, in our phrase, limited; and there is grave objection to the use of common terms in an unusual sense. But I apprehend that, by this restriction of our use of the word monopoly, we lead ourselves astray from the truth, because there is no fundamental difference between one kind of

monopoly and another. It is only in virtue of monopoly that articles have any value; it is only because A has something desirable which B has not that B will pay him for it. If no one desired to borrow capital, all possessing plenty, there would be no interest. This function of monopoly we can conceive to exhibit itself at a very early stage of civilisation. When one man has constructed a canoe before his neighbours, he has a monopoly of the shipping of his community, and it is in virtue of this that he imposes, most reasonably, a tax or impost for the use of his canoe. If I want a loaf of bread, and have not the means of baking one, the baker from whom I buy has a monopoly as against me; all the bakers have a monopoly as against the community, otherwise they would not be able to make the community pay for bread; it would be free as air. This monopoly of simple possession, moreover, though apparently of no very great importance as regards value, is capable of being made so. Thus, if I make myself unpopular with the bakers, and they agree to refuse me bread, their monopoly may cause me to find bread much more expensive than it was wont to be. And although this consideration is modified by the possibility of borrowing from my neighbours, yet it only requires a further spread of the conspiracy against me to cut off my supplies from this source also. Such a state of things is not only conceivable and possible in the present day, but has actually been brought about, if we are to believe some of the alleged cases of boycotting in Ireland.

We may now, I trust, freely use the term monopoly without any fear that it will still rest under the odium that has come to be attached to it. Monopoly is not only essential to value, but it is an essential even of the most elementary division of labour. That any human being can exist without subservience to it is inconceivable. The present proprietor may be landlord, farmer, and labourer, all in one; he may even bake his own bread, rear his own mutton, and grow his own wool. But he cannot also manufacture his ploughs, construct his oven, weave his cloth. Even if he could do all this, he cannot also grow the wood and work the mines necessary to provide machinery for his purposes. Monopoly, possession adverse to us, hedges us around on every side. When its influence is very small, as in the case of articles like bread, that can be produced in almost any quantity, it has little effect on value; in economic phraseology, the supply is large. As the stringency of the monopoly increases, so also does

its effect on value; the supply contracts. In certain cases—the genuine monopolies of the old school—the monopoly is very strict, and the effect on value immense; thus diamonds, exceeding skill, land in very favoured circumstances, possess the quality in a very high degree. But from these lordly possessions to the homely loaf, the distance, though great, is a gentle slope; at no point is there any wide gulf. Gold is less a monopoly than diamonds, and the baser metals than gold; skill, short of the very highest, has still a monopoly value, decreasing steadily till we reach the ordinary plodder who makes his livelihood with a struggle; land in the midst of great towns is followed by land in the suburbs, by land which may at any moment come into the market for building purposes, that again by fine agricultural soil, and so on, until we come to barren moors, when the monopoly is not good for any value, because of the absence of utility, otherwise demand. With manufactured articles the same rule holds good. In theory, steam-engines can be made *ad infinitum;* but no man, considering the machinery necessary as a preliminary to constructing a locomotive, will affirm that existing makers have no monopoly. The well-known maker of fine confections has a monopoly value for his confections, simply from the fact that his name is accepted as a guarantee of their excellence, while those of other makers are not. From one end to the other the effect of monopoly or value is a gradual incline all the way.

Monopoly in Relation to Distribution of Wealth.

Let us now begin to apply this principle to the distribution of wealth. We shall find it as well to fix our minds on some concrete example within the limits of industry, as the same economic terms cannot be applied to all, and the use of terms generally, which do not cover every case, is apt to lead to misunderstanding. The manufacture of some kind of goods in common use and demand will serve our purpose. Here there is, first of all, the rent of the ground on which the factory stands. The economic rent of this piece of land is the excess of the yearly value it will produce, when devoted to the most lucrative purpose for which it is fitted, over the yearly value of the worst land that could be used for that same purpose. The foregoing sentence seems to be involved at first sight, but an illustration will render it simple. Suppose I set up a factory in a fashionable part of London, my rental will be computed, not on the value of the

land for manufacturing purposes, but on its value as residential property. This principle is of universal application; and we must not be led astray in considering economic rent, which is merely the expression of advantage in some land over other land, by the fact that it differs frequently from the actual rent as paid in virtue of contract or some other disturbing influence.

It is, then, in consequence of the possession of superior land that the landowner receives rent; in other words, rent is the result of his monopoly of a commodity which is demanded. As the supply diminishes, the monopoly increases, and with it the value of the land. So far there is no difficulty, for land has come to be characterised as a "monopoly," both in common conversation and in economic writings. With the owner of the factory it is different; he has not been generally considered as the possessor of a monopoly. But if we divide his share into its component parts, we shall see how the action of monopoly affects him. First of all, there is interest; this is quite distinct from the other portions of the return to capital, and may be received by a different person, in the case when capital has been borrowed by the manufacturer. Interest depends on the demand for, and supply of, capital; the limitation of the supply is necessary to produce it; consequently it is dependent on the fact that some persons possess capital and other persons lack it. Interest is, therefore, due to a monopoly—not a strict monopoly in a country like ours, because the supply of capital is large. The next portion of the return to the manufacturer is what economists term earnings of management. We need not discuss the character of this portion, nor argue how far the terms "earnings" or "wages" are properly applicable to it; it is sufficient for us to note that it is the result of ability in the management of business. If the employer has no business ability, he will not derive any return from this source; the more capable he is in his special trade, the greater will be his earnings of management, because the more advantage will he have over his competitors. Thus it is, in virtue of monopoly also, that this portion of his gains comes to him; and the gains increase with the strictness of the monopoly which he possesses.

MONOPOLY OF CAPITAL EMPLOYED IN MANUFACTURES.

These two elements, however, are not an exhaustive analysis of the return derived by the employer or manufacturer. Interest is

practically constant; earnings of management cannot be supposed to be reaped by many individuals and companies who manage large businesses through agents and subordinates. We cannot by means of these alone account for the great returns earned in some industries. Suppose that the manufacturer whom we have chosen for our hypothesis be proprietor of a flourishing business with a great name; we have only to think of a few such concerns which all the world knows of to perceive that there must be for him some source of profit more productive than any that we have yet touched upon. Those sources that we have already noticed result from (1) the monopoly of capital in any form, and (2) the monopoly of ability to manage business. We may now add a third source, which is the monopoly of capital employed in the particular industry under consideration. This monopoly is caused by anything that limits, naturally or artificially, the supply of such capital, and, for want of a better term we may characterise the return derived from it by the manufacturer as business profits. To illustrate this element, suppose the employer has some special process in the manufacture of the article he deals in which others in the same business do not possess, and which enables him to make his goods better or to sell them cheaper than they. This we would call an artificial monopoly. If, however, the advantage is not the result of a secret method, but of a special genius on the part of the employer, we should call it a natural monopoly; and the return due to it is quite distinct from the same employer's earnings of management, which are derived from general business capacity only. The most common form of this business profit is in the case of large and well-established firms whose products practically hold the market; such articles as Bass's beer, Pears's soap, or Colman's mustard, endow their manufacturers with a monopoly which must produce a great business profit. Another form of the same thing is seen in the construction of large ships, which only a few shipbuilders have sufficient numbers of men in their employment to undertake at the short notice at which the ships are commonly required. This monopoly the capitalist (using the word in its wide sense) may maintain by using his position to crush out or prevent competition; or outside circumstances may interfere to assist him to maintain it. It may be observed that this business profit monopoly, like all monopolies, consists in a limitation of supply, and it may generally be assumed that this limitation is really due, in the first instance, to the superiority of the article produced. This superiority

must be put down to the special abilities of the maker at the time when his productions achieved distinction, and so a natural monopoly in course of time grows to be an artificial monopoly.

We have so far been considering the case of manufacture, but the same analysis may be applied equally to other industrial forms of the employment of capital. We have to be careful as to use of the term "product" when we discuss the relations between employer and employed, and in some trades it requires a little thought to apply it correctly. To illustrate the business profit of other industries, let us look at purely retail trade. In it the profits of the trader do not depend on the ratio between expense of production and price of sale, but on the number of sales effected. His original investment does not consist in the raw material and machinery necessary to produce the things that he deals in, but in his shop and premises. Similarly, in the carrying trade, profits depend on the number of goods and persons carried—in other words, on the quantity of traffic. The monopoly which produces business profits may exist in these cases just as in manufactures. By special acumen in the selection of articles on hand for sale, a quick appreciation of the tastes of customers, a retailer may establish for his place of business a name similar to that acquired by large manufacturing firms. When his turnover is large, again, a permanent reduction in the price of goods may, by greatly increasing the number of sales, permanently increase his profits, and create a monopoly in his favour as against the small shopkeeper, who cannot afford to lower his prices. Yet again, the mere improvement of the locality in the neighbourhood of his premises will cause increase in his business. The monopoly of the carrier does not require to be illustrated. With regard to the product of these trades, we may notice that the retail trade is, in truth, a carrying trade, and consists in bringing goods to the place where they are wanted, or, at least, in placing them where they can be most conveniently reached. The product in each case is that additional value which is given to goods by conveyance, by transference to places where their utility is increased. The expression of this increased value in money corresponds to the price of the product in manufacturing industry.

THIRD ELEMENT IN PROFITS: RISK.

It is worth while to observe that what used to be considered as the third element in profits—risk—is covered by the particular form

of monopoly just discussed. Risk, in proportion to its extent, prevents the crowding of an industry; consequently, it increases the returns to capital invested in that industry, solely because it limits the supply of capital so invested, and thus it creates an artificial monopoly and enhances business profits.

Our analysis of that share of the return to industry which is commonly called profits is now complete. We have seen the action of monopoly in the case of each portion of profits, and it is not necessary to recapitulate. One remark on the foregoing inquiry, however, may not be amiss. It is not instructive to speak of the general profits of a trade or industry. When we do so, we consider these trade profits as being limited by the extent to which monopoly of certain kinds assists all persons engaged in the trade, but fail to take into account other kinds of monopoly which affect individuals separately. Thus, when we say the profits in the retail spirit trade are large, we are thinking of certain special limitations in the supply of capital invested in that trade—for example, the general feeling of distaste towards it, and the legal restrictions to competition amongst publicans. These things must act as monopolies, and enhance generally the profits in the trade; but each retailer has other factors in his business which, as far as profits go, form monopolies or help to destroy the effect of the other monopolies. Thus A, whose hostelry is on a deserted coach road, will find that the supply of whisky there is too large for the demand, and his legal monopoly will avail him nought against dearth of sales; while B, whose modest house of refreshment comes to be the centre of a populous district, will possess a monopoly more lucrative by far than the common privileges of his trade. The general profits of the cotton-spinning trade are as much a mere empty name to the successful C, who inherited a business with fine connections, and is worth a million, as they are to poor D, who started in the same line ten years ago, and whose last thread was snapped in the bankruptcy court the other day. It is often useful to notice the limitations to supply which affect a whole branch of trade; but it is worse than useless to ignore those others which affect individuals in that branch.

It is not within the scope of this paper to attempt the analysis of wages, which is a far more difficult and intricate matter. But no investigation of what is called the labour question—which I take to mean how to ensure to labour its due share of the gross

amount earned, and to diffuse the demand for remunerative labour as widely as possible—is possible without a clear understanding of the nature of profits, for both are claimants on the same fund, and the validity of the claim of each must be judged with reference to the claim of the other. The preceding analysis may be expanded thus—a capitalist makes his profits out of a variety of sources. First of all, there is interest, which is simply the amount which he gets for having a monopoly in the possession of capital, apart from any special use that he may put it to. It is what the loan of money will fetch, if we give it into safe hands, and allow the custodier to employ it as suits him best. Observe that money, although the most convenient form of loan to the debtor, is generally cheaper to hire than other commodities, because, being indestructible, pure interest alone is paid on it, and not a portion of the price for wear and tear.

EARNINGS OF MANAGEMENT.

Next, there are earnings of management, strictly so-called; these are determined by the demand for, and supply of, business power, and are indicated by the salaries of competent managers, just as interest is shown by the return for consols or other good securities. These alone are really the price paid for managing business. Then there are a variety of gains which may or may not find their place in the profit of an individual capitalist, and which I have summed up as business profits. The most prominent of these is the monopoly which extra or special skill gives to its possessor. This is most frequently the origin or foundation of other kinds of monopoly. Thus a man makes some article particularly well, through application of his mind to the taste of the public, or to the uses the article is to be put to. He establishes, we will suppose, a great sale of the article; supposing it is made by machinery, he will not require much extra expenditure of capital to increase very largely his gross drawings. He will probably be able to charge a higher price than his neighbours. In time, the command of the market thus created is such that the sale will not be appreciably depressed although the article is no longer kept up to its earlier excellence. Or, it may be, that other people invent something equally good, but are unable to capture the ground held by the original discoverer. If you compiled and published a time-table as good as "Bradshaw's," and less illegible, and sold it for 5d., you

would yet spend many years and many thousands of pounds before you drove that "railway veteran" into a siding.

Monopoly of Custom.

There is, and was, the monopoly of custom, which often subsists with no other ground for its existence. There is also the gain which arises from a monopoly the creation of which is due to causes of which the capitalist has no control. I have heard it stated—and I believe it to be true—that the invention of the sewing machine gave a great impetus to the manufacture of thread. This effect, however, would only be a temporary one; but there are instances in which the result is permanent. Thus a hotel has its custom increased by the advent of a railway to its neighbourhood; a shop becomes more valuable when buildings spring up round it; a railway in a locality like the mineral district of Lanarkshire gains through the opening of the coalfields. There is also a certain gain in some kinds of trade due simply to the fact that an enormous outlay of capital is required in them, and that individuals, unless by means of association, are virtually precluded from entering them. Then there is the important matter of the attractive or deterrent character of the business itself, the most important feature of which is the risk of loss attaching to it. It is, perhaps, owing to the adventurous spirit in human nature that risk, from the statistics we possess, is, on the whole, decidedly underrated. In public companies, whose trade is pecuniarily of a speculative nature, the average returns are lower than in those of a more solid kind, whereas they ought to be identical, were it not that the monopoly which risk ought to confer is somewhat diminished by the public taste for speculation.

There is still a class of gains which accrue owing to the action of law. The limitation of the investments which trustees are empowered to make may have some slight effect in this way; but it is in its more direct action that positive legislation has its most important consequence. The limitation of the retail spirit trade by licenses produces a monopoly value which is probably shared, in practice, between rent and profit. A railway company in Great Britain is granted by Parliament, for public reasons, a monopoly—a *quasi* monopoly—of conveyance; and Parliament, as a corollary to this, fixes the price of carriage. In the few monopolies which are controlled entirely by the Government service we can see something

of the action of this principle, because we have the precise figures. The Post Office produces a very large revenue; the inference cannot be questioned that we are in the habit of sending letters, as a rule, above cost price. The telegraph service is a loss; so we may take it for granted that we send telegrams below cost price. Why the letter writers should subsidise the telegram writers is a problem the simple economist must leave to the complex mind of the legislator. I suppose a letter is a luxury in modern life that ought to be taxed, while a telegram is the poor man's method of communication, and ought therefore to be encouraged. It is also possible that a monopoly may be created by arrangements between traders themselves. Retail traders often bind themselves to deal with large wholesale firms exclusively in some kind of goods, in consideration of reduction in price or some other advantage. In the spirit trade we are familiar with "tied" houses, as they are called.

Conclusion.

I do not profess to have enumerated all the ways in which profits are made up. What I want to show is that, instead of being composed of one or two simple and homogeneous elements, they comprise a great many classes of gains of great variety. A slight consideration of these has led us to observe that to speak of the general profits of a trade is misleading, for there cannot, properly speaking, be any; and we may go on to affirm that all profits are individual profits. This, though it should affect our views on taxation and other matters, is of special importance just now because of its bearing on questions of labour. In the great group of trades called the retail trades, which, for economic purposes, must be held to include the carrying trades—for *retail* is simply distribution of goods,—the Acts of trades-unions or of the legislature will have different effects on different branches, and on different individuals in the same branch. I have often heard that large shopkeepers are in favour of early closing by law. I do not know whether it is true, but, if they are alive to their own interests, it must be. The well-established tradesman has nothing to lose, and everything to gain, by early closing; no foreign competition threatens him, and his only fear comes from the smaller and less conspicuous men, who have to grasp at all the odds and ends of extra hours to keep their heads above

water. A restriction in the hours of labour in any trade will have a result on each capitalist affected in accordance with his own individual position. It is quite erroneous to argue that, because one manufacturer is able to make good profits under a particular system of working, all those engaged in the same business will do so, or ought to do so. In brief, what I wish to emphasise is, that profits are in a sense homogeneous, in that they are all derived from some scarcity—a monopoly; and that, in classifying profits, we ought not to divide them according as they are derived from different kinds of trade or business, but as they are the outcome of one or another kind of monopoly. What I have called, in an earlier part of this paper, business profits, is simply a conglomeration of gains derived from monopoly after the classical terms of interest and wages of superintendence are deducted; but these last do not differ in kind from the former. I believe that it is by working of lines of analysis similar to those which I have duly indicated that economists may be able to give that scientific assistance which they ought to supply in the solution of questions of Capital and Labour.

VII.—*Comparative Tests of Hellesen and E.C.C. Dry Battery Cells.* By Professor Jamieson, M.Inst.C.E., F.R.S.E., &c., The Glasgow and West of Scotland Technical College.

[Read before the Society, 22nd March, 1893.]

Preliminary Remarks.

Advantages of Dry Cells.

It has been pointed out that dry cells possess certain practical advantages over wet batteries for bell calls, telegraphic, telephonic, medical, and military purposes. For laboratory work their unbreakableness, compactness, portability, cleanliness, and freedom from accumulating crystals, and the creeping of salts to the outside of the containing vessel, as well as the fact that they are always ready for use, and may be laid on their sides or even upside down, are evident advantages.

In the autumn of 1891 I happened to read an excerpt from a report on an exhaustive and carefully conducted series of tests by Messrs. Krehbiel, Narr, and Donle, of Munich, on six different kinds of "dry cells."* This report seemed to show that the "Hellesen" cell was the best.

I was, therefore, anxious to give the Hellesen dry cells a trial, and obtained at the beginning of last session (October, 1891) about forty of them from Messrs. Siemens Bros., of London, for use in the Electrical Engineering Laboratory of the Technical College. These cells have been employed since then by the students, principally for copper and insulation resistance and capacity tests, as well as for ringing bells, &c. They have unquestionably proved themselves to be much more convenient for such purposes than the previously used Daniell, Leclanche, Grove, Bunsen, and bichromate cells.

* The original report appeared in the "Elektrotechnische Zeitschrift" of 1st August, 1890, vol. II., No. 31, and an extract in "The Electrician" of February 6th, 1891, p. 419, vol. XXVI.

About this time last year I got a few E.C.C. dry cells from Mr. G. Binswanger, Managing Director of the General Electric Company, London, and, from their general behaviour in the laboratory, I formed the opinion that they were quite as good as those of the Hellesen type. In order, however, to make a set of comparative tests, I procured a couple of quite new Hellesen and E.C.C. cells of about the same weight, and again referred to the Munich report, from which I herewith give the following extract, in order to show that I was comparing the E.C.C. cell with a type of cell which had been proved to be the most efficient of six of the principal dry batteries.

Extract from the Munich Report.

"The most efficient cells, even for circuits of small external resistance, are the Hellesen and the Bender, the former having the advantage of less polarisation and much smaller internal resistance; the Hellesen cell has, however, when exhausted by long working, not quite so much recuperative power as the Bender."

*Total ampere-hours on closed circuit through an external resistance of 50 ohms for 96 hours.**

Hellesen, ...	2·3915 ampere-hours.
Bender, ...	2·3400 ,, ,,
Thor, ...	2·1435 ,, ,,
Gassner, ...	1·9374 ,, ,,
Jenisch, ...	1·0347 ,, ,,
Wolfschmidt, ...	0·5967 ,, ,,

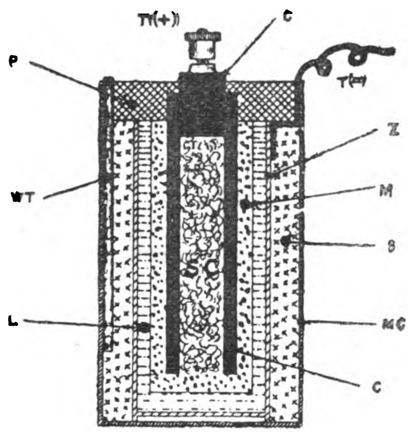
*Total ampere-hours on closed circuit through an external resistance of 3 ohms for 24 hours.**

Hellesen, ...	5·0792 ampere-hours.
Bender, ...	4·9898 ,, ,,
Thor, ...	3·4552 ,, ,,
Gassner, ...	2·6670 ,, ,,
Jenisch, ...	1·2236 ,, ,,
Wolfschmidt, ...	1·6168 ,, ,,

* These cells are reported to have been in each case of nearly the same size as the Hellesen type No. 2 frequently referred to later on.

GENERAL DESCRIPTION AND CHEMICAL CONSTITUENTS OF THE HELLESEN AND E.C.C. DRY CELLS.

The following sectional drawings have been made by one of my laboratory students, Mr. D. Cameron, from sawn sections of the cells, and I am indebted to Dr. Henderson, Professor of Chemistry in the Technical College, for the chemical analysis :—



VERTICAL DIAGONAL CROSS SECTION.—HELLESEN CELL.

Index to Parts.

T (+)	represents	Terminal positive.	Z	represents	Zinc containing vessel.
C	,,	Carbon (bored hollow).	T (—)	,,	Negative terminal wire.
SC	,,	Silicate cotton.			
M	,,	Manganese dioxide, &c.	S	,,	Sawdust packing.
			P	,,	Pitch (top covering).
L	,,	Lime & sal-ammoniac, &c.	MC	,,	Millboard case.
			WT	,,	Waste tube.

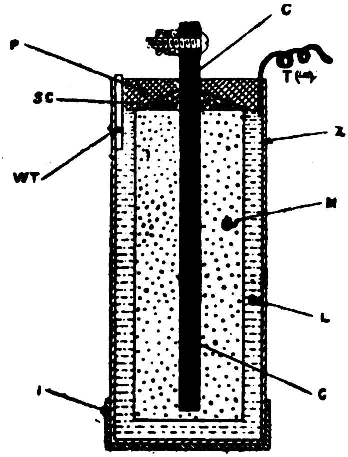
ANALYSIS OF HELLESEN CELL.

Black Paste (M).

Carbon, ...	= 16·02
SiO_2, ...	= 12·76
MnO_2, ...	= 31·29
Fe_2O_3, ...	= 3·46
MgO, ...	= 12·88
CaO, ...	= 0·96
Cl, ...	= 3·37
H_2O, ...	= 12·02
Organic matter, &c., ... (by difference)	= 7·24
	100·00

White Paste (L).

CaO, ...	= 26·18
MgO, ...	= 0·51
ZnO, ...	= 6·00
NH_3, ...	= 2·49
Cl, ...	= 7·35
H_2O, ...	= 35·78
Organic matter, &c., ... (by difference)	= 21·69
	100·00



VERTICAL CROSS SECTION.—E.C.C. CELL.

Index to Parts.

T (+)	represents	Terminal positive.	Z	represents	Zinc containing vessel.
C	,,	Carbon.	T(—)	,,	Negative terminal wire.
SC	,,	Cotton.			
M	,,	Manganese dioxide, &c.	P	,,	Pitch (top covering).
L	,,	Lime & sal-ammoniac, &c.	I	,,	Insulating base.
			WT	,,	Waste tube.*

ANALYSIS OF E.C.C. CELL.

Black Paste (M).

Carbon, ...	= 36·30
SiO_2, ...	= 10·96
MnO_2, ...	= 22·75
Fe_2O_3, ...	= 2·12
MgO, ...	= 7·20
CaO, ...	= 1·40
NH_3, ...	= 1·27
Cl, ...	= 3·49
H_2O, ...	= 9·77
Organic matter, &c., ... (by difference)	= 4·74
	100·00

White Paste (L).

CaO, ...	= 20·89
NH_3, ...	= 2·03
Cl, ...	= 6·31
H_2O, ...	= 28·68
Organic matter, &c., ... (by difference)	= 42·09
	100·00

* This short glass tube should have been drawn with its lower end terminating in the cotton at SC. These tubes in both cells are evidently to carry off any waste gas.

FIRST SERIES OF TESTS OF THE HELLESEN AND E.C.C. DRY CELLS.

(Taken during April, 1892, by Messrs. D. A. Ramsay and J. F. Nielson.)

Table of Weights and Dimensions.

	Weight.	Dimensions.
No. 3 Hellesen,	1·67 lbs.	5·5″ × 2·5″ × 2·5″
No. 2 E.C.C.,	1·92 ,,	6″ × (2·5 diameter).

Initial and Final E.M.F.'s and Currents, with total ampere-hours.

(1) On closed circuit, through an external resistance of 5 ohms for 50 minutes :—

	E.M.F. IN VOLTS.		CURRENT IN AMPERES.		OUTPUT IN AMPERE-HOURS.
	Initial.	Final.	Initial.	Final.	Total.
No. 3 Hellesen,	1·430	1·255	0·230	0·222	0·183
No. 2 E.C.C.,	1·455	1·287	0·248	0·229	0·197

(2) After 24 hours' rest, the E.M.F.'s of the same cells were taken, and they were again short-circuited through an external resistance of only 2 ohms for 50 minutes—readings being taken every 5 minutes, as in the previous case :—

	E.M.F. IN VOLTS.		CURRENT IN AMPERES.		OUTPUT IN AMPERE-HOURS.
	Initial.	Final.	Initial.	Final.	Total.
No. 3 Hellesen,	1·355	1·126	0·446	0·389	0·338
No. 2 E.C.C.,	1·393	1·079	0·509	0·434	0·389

E.M.F. after being short-circuited.

(3) After another rest of 24 hours, the same two cells were short-circuited by joining their terminals directly together. Observations of their E.M.F.'s were then made after 15 minutes;

again short-circuited for other 15 minutes, and similar readings taken; and, finally, short-circuited for 23 hours, and the E.M.F. recorded.

The following Table gives the results obtained :—

Cell.	Electro-Motive Force in Volts.		
	After 15 Minutes.	After 30 Minutes.	After 23·5 Hours.
No. 3 Hellesen,	0·966	0·928	0·167
No. 2 E.C.C.,	1·104	1·054	0·597

Current and ampere-hours observed whilst short-circuited.

(4) A new pair of cells of the same size as before—namely, a No. 3 Hellesen and a No. 2 E.C.C.—were short-circuited through the very small external resistance of the thick copper wire of a Helmholtz tangent galvanometer. Current readings were taken by this instrument every 3 minutes for a period of 54 minutes :—

Cell.	Current in Amperes.		Ampere-hours.
	Initial.	Final.	Total.
No. 3 Hellesen,	2·07	0·8	0·95
No. 2 E.C.C.,	4·7	1·75	2·18

In this first series of tests, over 200 observations were made, not only for E.M.F. current and internal resistance, but also to ascertain their efficiency as accumulators. We have, however, so many other results of a similar kind to lay before you in describing the second and the third series of tests, that we think it advisable not to overload this paper with them.

Second Series of Tests of the Hellesen and E.C.C. Dry Cells.

(Taken during November and December, 1892, by Messrs. F. Carleton Anderson, J. Bisset George, and W. B. Wilson.)

The new cells placed at my disposal were measured and weighed, as recorded in the following Table :—

Table of Cells as Paired for Approximate Weights.

Excess of Weight shown in last two columns.

E.C.C.			Hellesen.			Excess.	
No.	External Dimensions.	Weight.	No.	External Dimensions.	Weight.	E.C.C.	Hellesen.
		lbs.			lbs.	lbs.	lbs.
1.	7″ × (3″ diameter).	3·36	1.	7″ × 4″ × 4″	5·56	...	2·2
0.	4·75″ × 4·5″ × 2″	3·11	2.	6·5″ × 3″ × 3″	2·89	·22	...
2.	6″ × (2·5″ diameter).	1·92	3.	5·5″ × 2·5″ × 2·5″	1·67	·25	...
3.	5″ × (2″ diameter).	1·11	4.	5·375″ × 2·25″ × 2·25″	1·43	...	·32
4.	3·875″ × 1·5″ × 1·5″	0·656	6.	3·75″ × 1·5″ × 1·5″	0·51	·146	...

Current and Potential Difference.

The following method was devised to enable tests to be made with *one* galvanometer for measuring both the current and the potential difference :— *

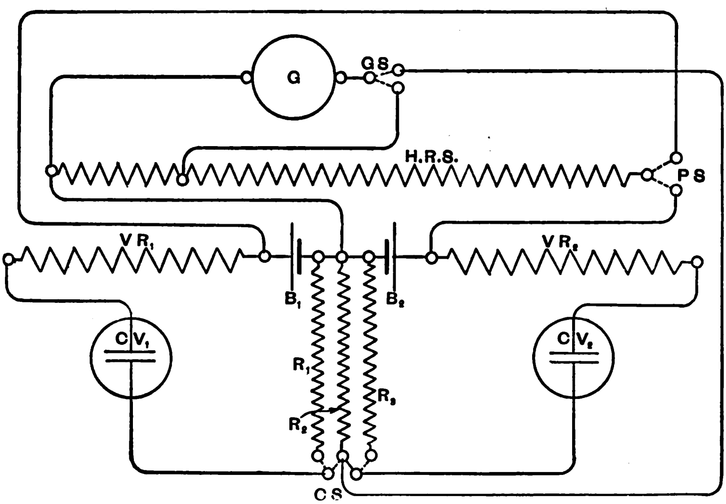


DIAGRAM OF CONNECTIONS FOR MEASURING THE CURRENT AND POTENTIAL-DIFFERENCE OF THE DRY CELLS, USING ONLY ONE GALVANOMETER.

* In the first series of tests, the electromotive force (E.M.F.) was observed. In the second and third series of tests, not only the E.M.F (in certain cases), but also the potential difference (P.D.) or electrical pressure

Index to Parts.

B_1, B_2	represent the 2 cells to be compared.	CS	represents	Current switch.
VR_1, VR_2	,, 2 variable resistances.	HRS	,,	High resistance shunt.
CV_1, CV_2	,, 2 copper voltameters.	G	,,	Galvanometer.
R_1, R_2, R_3	,, resistances.	GS	,,	Galvanometer switch.
		PS	,,	Potential switch.

When measuring the potential difference, the galvanometer was connected across a part of the high resistance shunt, HRS. This resistance could be joined up between the poles of either cell by simply turning the potential switch, PS, as shown in the diagram. The two resistances, R_1 and R_3, were each made as nearly as possible equal to R_2. The current to be determined was passed through the resistance R_2, and the potential difference at its extremities was measured by the galvanometer G.

Before each test the galvanometer scale was carefully calibrated for measuring the potential by means of a Dr. Fleming's standard cell (E.M.F. = 1·072 volts, according to the latest Board of Trade standard). The values of the scale readings for the current measurements were determined from the weight of the copper deposited in the copper voltameters CV_1 and CV_2.

Potential Current (Test No 1).

The following series of observations was commenced with new cells, No. 1 E.C.C. and No. 2 Hellesen. Both cells were allowed to discharge at a certain current strength, as adjusted by VR_1 and VR_2, for about four minutes, before the potential difference was taken, thus giving the cells time to polarise. The initial and final results are given in the following Table, and the whole of

---

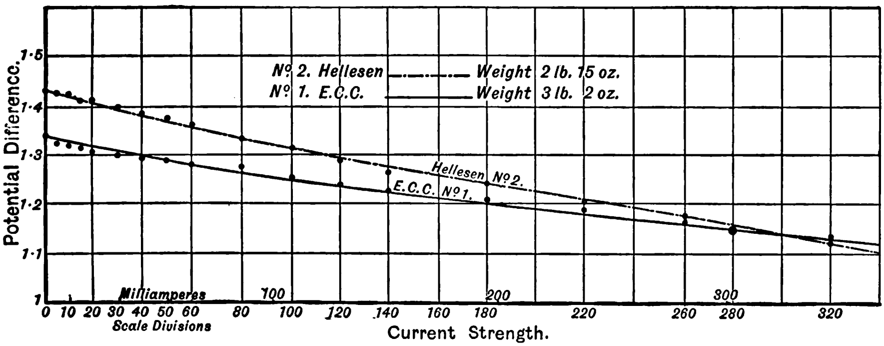
between the terminals, was taken. We distinguish between the E.M.F. and the P.D. in the following manner. The E.M.F. is the *total* electrical pressure generated *inside* the cell. The P.D. is the electrical pressure between the terminals of the cell, and is always less than the E.M.F. by the amount constituting the fall of pressure within the cell necessary to maintain the current flowing through the cell at the time of observation.

Or E.M.F. = P.D. + $C_c \times R_c$. Where C_c is the current flowing through the cell and R_c is the resistance of the cell. If C_c = o , then the P.D. = the E.M.F.

the observations are plotted in the Potential Current Curves (No. 1):—

CELL.	POTENTIAL DIFFERENCE IN VOLTS.	
	Initial.	Final.
No. 2 Hellesen, ...	1·43	1·103
No. 1 E.C.C., ...	1·34	1·118

POTENTIAL-CURRENT CURVES (No. 1).



The ordinates of these curves represent the potential differences at any current strength as given by the abscissæ. The changes made in the current were "step-down." The potential difference was observed in each case after the current had remained steady for 4 minutes.

(Tests taken during December, 1893.)

Potential Time (Test No. 2).

In this case the same cells as in *Test No. 1* were used. The current was kept constant by varying the resistances VR_1 and VR_2, and the potential difference was measured every *ten* minutes. The E.C.C. started at 1·255 volts, while the Hellesen started at 1·285 volts, and after 2 hours 55 minutes the E.C.C. gave 1·175 volts, and the Hellesen 1·110 volts; thus showing that the E.C.C. kept up its voltage better than the other cell under the same working conditions.

CELL.	POTENTIAL DIFFERENCE IN VOLTS.	
	Initial.	Final.
No. 2 Hellesen, ...	1·285	1·11
No. 1 E.C.C., ...	1·255	1·175

Potential Time (Test No. 3).

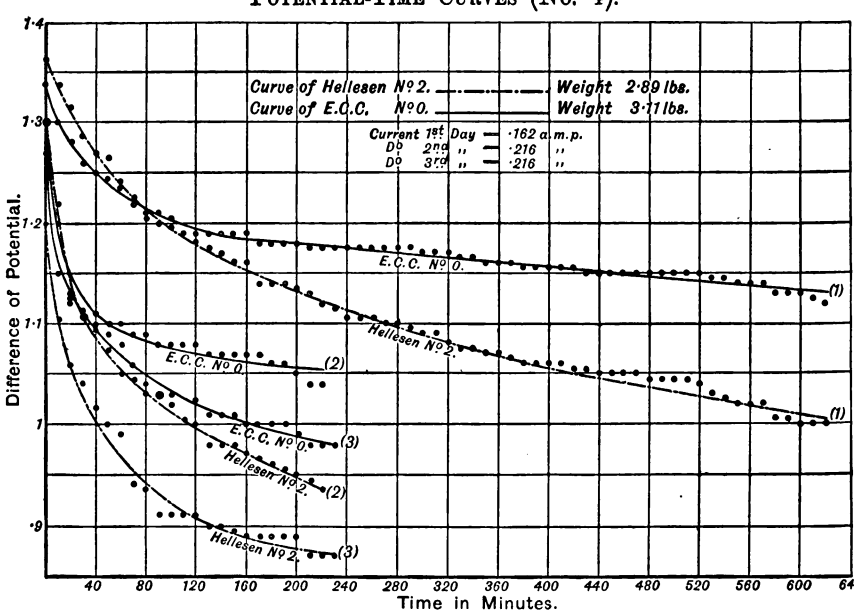
After a rest of about 20 hours, the same cells were again tested for 2 hours 35 minutes, to ascertain the recuperative effect due to rest.

CELL.	POTENTIAL DIFFERENCE IN VOLTS.	
	Initial.	Final.
No. 2 Hellesen, ...	1·22	1·09
No. 1 E.C.C., ...	1·21	1·17

Potential Time (Test No. 4).

New cells (No. 2) Hellesen and (No. 0) E.C.C. were now tried with a constant current of 0·162 ampere. The current was regulated as before by the variable resistances VR_1 and VR_2. The test was started at 9.45 a.m., and continued for 12 hours without stopping. The results are plotted in the accompanying curves (1) and (1). The Hellesen cell deposited during these 12 hours 2·561 grammes, and the E.C.C. in the same time 2·517.

POTENTIAL-TIME CURVES (No. 4).



The ordinates of these curves represent the potential differences at any time as given by the abscissæ. The current was kept constant.

(Tests taken during December, 1892.)

These same two cells were again tested for a period of 3 hours 40 minutes. The results are plotted in curves (2), (2). Finally they were tested for 3 hours 50 minutes, and the results are shown by the curves (3) and (3). The current in the latter two cases being 0·216 ampere.

Third Series of Tests of the Hellesen and E.C.C. Dry Cells.

(Taken by Messrs. J. Fred. Nielson and Forbes W. Bruce.)

The students having gained more experience in the taking of such tests, my assistant, Mr. Andrew Gray, arranged for the following more complete scheme of observations, in order to determine—

Firstly.—The *fall of potential* while on closed circuit and maintaining approximately the *same current* throughout the whole of the test.

Secondly.—The *variation of the potential difference* at the terminals of each cell *due to the variation of the current strength* in its external circuit.

Thirdly.—The *apparent internal resistance* of each cell at *different current strengths.*

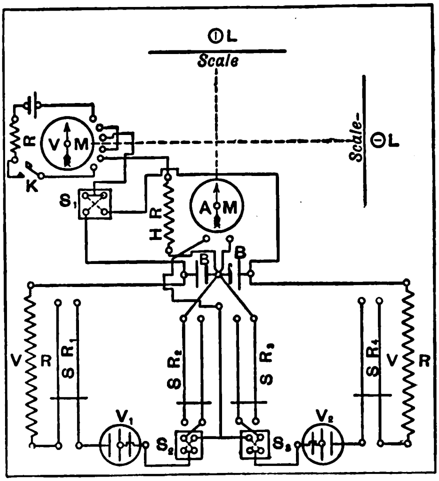
Fourthly.—The *recuperativity* and the *time-rate of the rise of electromotive force* after being short-circuited until as nearly as possible exhausted.

Fifthly.—The *total available external energy* (or number of watt-hours expended in the external circuit of each cell, discharging through a constant resistance until practically exhausted); also the *total number of ampere-hours* obtained from each cell.

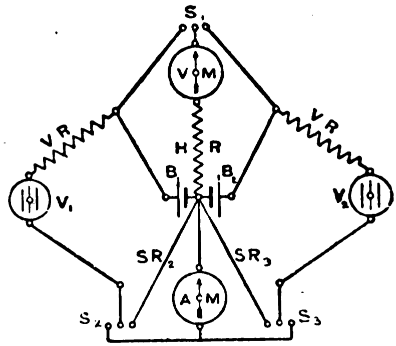
Sixthly.—The percentage *reduction of the electromotive force due to polarisation.*

In these tests, cells of as nearly as possible equal dimensions

were paired against each other, as shown by the previous Table of weights and their dimensions.



WORKING DIAGRAM.



THEORETICAL DIAGRAM.

Index to Parts.

B	represents	Battery.	VR	represents	Variable resistance.
VM	,,	Voltmeter.	SR	,,	Sliding resistance.
AM	,,	Ammeter.	S	,,	Switches.
V_1,V_2	,,	Voltameters.	K	,,	Key.
HR	,,	High resistance.	L	,,	Lamps.

Rearrangement of Apparatus for Testing Hellesen and E.C.C. Dry Cells.

The method employed was that of using two galvanometers—one of high resistance to measure the potential difference, and the other of low resistance to measure the current strength.

In those tests in which a constant current strength was maintained throughout, a voltameter (see Figs. 1 and 2) was included in each circuit, so that the current could be accurately measured by the weight of copper deposited. Resistance boxes, together with slide resistances, were employed to vary the resistance in the circuit. Each cell was joined up with its own separate circuit, and the apparatus was so arranged that the potential difference at the battery terminals, and the current flowing in each circuit, could be measured by merely switching each cell in turn on to the voltmeter (VM) and the ammeter (AM).

The high resistance astatic mirror galvanometer of 45,000 ohms, which was used as the voltmeter, had in circuit with it a resistance of 100,000 ohms, so that the total resistance amounted to about 145,000 ohms, and was so controlled that the deflection produced by Dr. Fleming's standard cell (E.M.F. = 1·072 volts) was 536 divisions. Thus, the value of a scale division was 0·002 volt, and to obtain the value in volts of any potential difference, the deflection had only to be multiplied by that number.

The low resistance mirror galvanometer was under strong magnetic control and shunted by a short wire, and was calibrated to read in milliamperes by the ordinary copper deposition method.

Paraffin blocks, with mercury cups, were used as switches, and the connections were made by inserting stout copper wire cross-pieces. The working arrangement of the apparatus is clearly shown on the left hand side of the above drawing, and the theoretical diagram on the right.

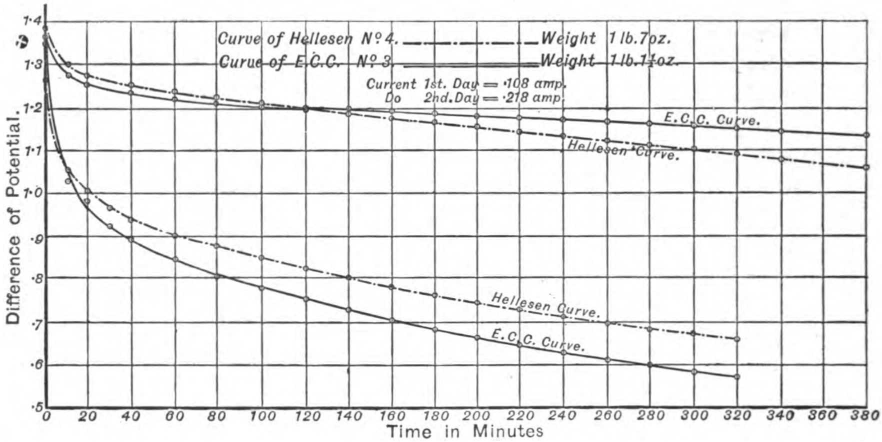
Potential Time (Test No. 1).

In this test the cells paired against each other were a No. 4 Hellesen and a No. 3 E.C.C.

The current through each circuit was kept at a constant value—namely, 0·108 ampere throughout the whole test, for a period of eight hours. Readings were taken every ten minutes, and a few of these are here tabulated :—

Time in Minutes.	Hellesen. P.D. Volts.	E.C.C. P.D. Volts.	Time in Minutes.	Hellesen P.D. Volts.	E.C.C. P.D. Volts.
0	1·366	1·378	190	1·158	1·188
10	1·296	1·270	220	1·144	1·180
20	1·274	1·266	270	1·120	1·170
40	1·252	1·242	330	1·090	1·154
70	1·230	1·222	390	1·066	1·142
100	1·210	1·208	450	1·046	1·130
130	1·194	1·202	480	1·040	1·280
160	1·178	1·194			

POTENTIAL-TIME CURVES (No. 1).



(Tests taken in December, 1892.)

The two upper curves were obtained from the above tests by plotting down the potential differences as ordinates, and the time in minutes as abscissæ.

After 18 hours' rest, the cells were restarted, and a similar set of readings was taken. The two lower curves on the previous diagram were drawn therefrom. The external resistance was, however, reduced, so that the current strength attained a value throughout of 0·218 ampere, instead of 0·108 ampere.

The following Table gives a limited number of the readings so obtained (*see the two lower curves on the previous diagram*):—

TIME IN MINUTES.	HELLESEN. P.D. Volts.	E.C.C. P.D. Volts.	TIME IN MINUTES.	HELLESEN. P.D. Volts.	E.C.C. P.D. Volts.
0	1·266	1·354	160	0·792	0·712
10	1·050	1·016	190	0·766	0·682
20	1·002	0·964	220	0·742	0·652
40	0·946	0·900	250	0·714	0·628
70	0·894	0·826	280	0·694	0·610
100	0·844	0·786	310	0·676	0·586
130	0·820	0·748			

Potential Current (Test No. 2).

For this test, *a new set* of cells of the same sizes was taken—namely, a No. 4 Hellesen and a No. 3 E.C.C.

The copper voltameters were removed and the low resistance galvanometer was so calibrated that the value of any deflection produced was known in milliamperes.

The two cells were joined up as before, and their E.M.F. measured. A current of a certain value was obtained from them *alternately for a period of four minutes.* At the end of that time, the potential difference and the current were simultaneously noted.

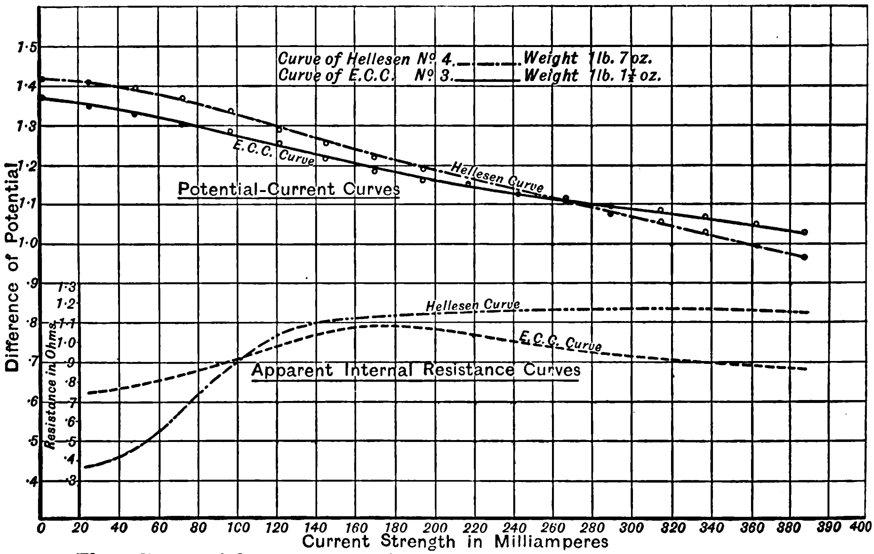
The external resistances (VR and SR) were then reduced, so that the current was increased by an equal amount each time, until it had risen in value from 0·024 ampere at the start, to 0·387 ampere at the finish. Sixteen double readings were thus obtained from each cell. The two upper curves were plotted down from these results. The potential differences are represented by the ordinates, and the current strengths in milliamperes by the abscissæ in the two upper curves of the following diagram.

The following is a Table of the results :—

Current Amperes.	HELLESEN. P.D. Volts.	E.C.C. P.D. Volts.	Current Amperes.	HELLESEN. P.D. Volts.	E.C.C. P.D. Volts.
0·0000	1·414	1·366	0·2178	1·164	1·148
0·0242	1·405	1·348	0·2420	1·134	1·126
0·0484	1·392	1·326	0·2662	1·106	1·112
0·0726	1·366	1·302	0·2904	1·074	1·094
0·0968	1·338	1·282	0·3146	1·064	1·080
0·1210	1·286	1·250	0·3388	1·020	1·064
0·1452	1·254	1·212	0·3630	0·996	1·044
0·1694	1·222	1·182	0·3872	0·968	1·028
0·1936	1·192	1·162			

POTENTIAL CURRENT AND APPARENT RESISTANCE CURVES

(Nos. 2 and 3).



The ordinates of the upper pair of curves represent the potential differences at any current strength as given by the abscissæ. The P.D. for any current was taken after the current had remained steady for 4 minutes.

The ordinates of the lower pair of curves represent to a reduced scale the apparent internal resistances at any current as given by the abscissæ.

(Tests taken during January, 1893.)

*Apparent Internal Resistance (Test No. 3).**

Curves of the "*Apparent Working Resistances*" of the cells are plotted in the previous figure, No. 3. These were obtained by calculation, *on the assumption that the electromotive force of the cells did not vary with the variation of the current strength.* As

* In testing cells for resistance, we generally endeavour to separate the resistance from the back E.M.F. of polarisation, and thus get the true resistance of the cell by itself or $(r_1 + r_2)$ in the formula—

$$\text{P.D.} = \text{E} - e - c\,(r_1 + r_2).$$

Where—

P.D. = potential difference between the terminals of cell.

E = E.M.F. of the cell, or P.D. on open circuit.

e = back E.M.F. of polarisation.

c = current flowing through the cell.

$(r_1 + r_2)$ = internal resistance of the cell when the current c is flowing.

r_1 = initial resistance of the cell, or resistance on open circuit.

r_2 = actual extra resistance due to effects of current c, such as gas-bubbles decreasing the effective area of the carbon plate.

will be seen from the curves, the apparent resistance of the Hellesen cell increased gradually with the current strength; whereas the resistance of the E.C.C. (although higher originally) and increasing at first, afterwards fell as the current became stronger. This peculiar variation of apparent resistance in the latter case agrees with the results obtained in the watt-hour test, detailed further on.

The following are some of the calculated values in ohms:—

Amperes.	HELLESEN. Ohms.	E.C.C. Ohms.	Amperes.	HELLESEN. Ohms.	E.C.C. Ohms.
0·0242	0·372	0·744	0·1936	1·147	1·054
0·0484	0·454	0·826	0·2420	1·157	0·992
0·0968	0·785	0·867	0·2904	1·170	0·937
0·1452	1·101	1·066	0·3388	1·163	0·891
0·1694	1·133	1·088	0·3872	1·152	0·871

Recuperativity (Test No. 4).

This test was carried out to determine the recuperativity and the time-rate of the rise of the electromotive force of the cells after being short-circuited until they were as nearly as possible exhausted.

Two new cells—namely, a Hellesen No. 3 and E.C.C. No. 2—were taken, and each was short-circuited by joining the wire from the negative pole to the positive terminal, so that the external resistance was practically *nil.* They were left then to discharge for 48 hours. By this means the E.M.F. of each cell was reduced to about 0·07 volt.

The following table shows the rate of increase of the E.M.F. after opening their circuits. Readings were taken at frequent

But in practice it is desirable to have formulæ as simple as possible. We therefore put the formula—

$$\text{P.D.} = \text{E} - e - c\,(r_1 + r_2).$$

$$\text{in the form P.D.} = \text{E} - c\,(r_1 + r_2 + r_3).$$

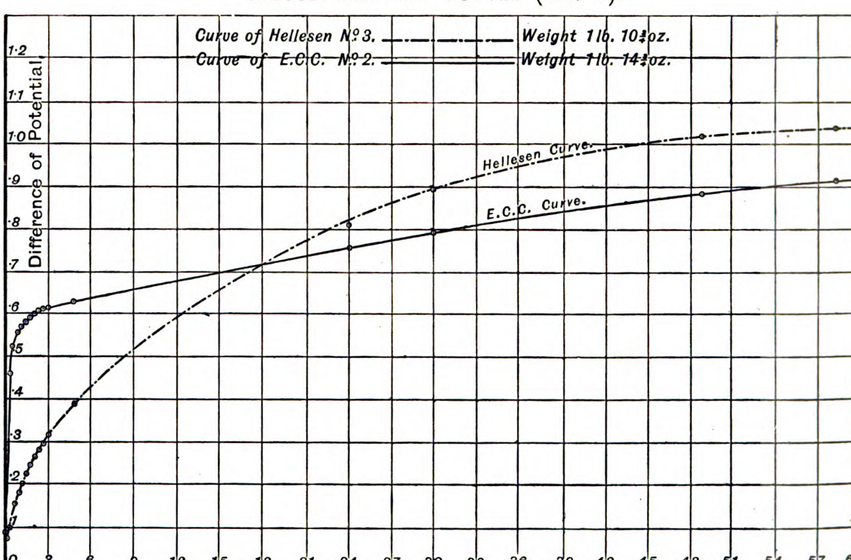
$$i.\,e.,\ \text{P.D.} = \text{E} - c\,\text{R}.$$

Where r_3, an imaginary extra resistance, is of such a value that the fall of potential through it would be equal to the E.M.F. of polarisation, or $c\,r_3 = e$. And R = the sum of these several resistances $(r_1 + r_2 + r_3)$ which we have called the "*Apparent Internal Resistance*" of the cell. This is a variable, depending on the current through the cell.

intervals. The following curves (No. 4) were obtained from these readings. The ordinates represent the E.M.F. and the abscissæ the time. Only a few of the readings obtained are given below :—

Time in Minutes.	Hellesen. E.M.F. Volts.	E.C.C. E.M.F. Volts.	Time in Minutes.	Hellesen. E.M.F. Volts.	E.C.C. E.M.F. Volts.
0	0·070	·074	90	0·224	0·584
2	0·086	·300	120	0·252	0·594
5	0·096	·362	160	0·292	0·608
7	0·100	·404	200	0·334	0·622
10	0·110	·416	250	0·372	0·630
15	0·116	·458	290	0·392	0·646
			Hours.		
20	0·122	·486	24	0·780	0·756
30	0·142	·512	30	0·896	0·792
40	0·160	·542	48	1·018	0·888
50	0·174	·554	57	1·038	0·916
70	0·196	·568	96	1·074	0·974

Recuperativity Curves (No. 4).



The ordinates of these curves represent the E.M.F. at any time as given by the abscissæ.
(Tests taken during January, 1893.)

Total Output in Watts (Test No. 5).

This test was made to determine the total output in watts, and the total number of ampere-hours from the following cells whilst

discharging continuously through a known constant resistance for a period of seventy-two hours *(see Curves No. 5)*:—

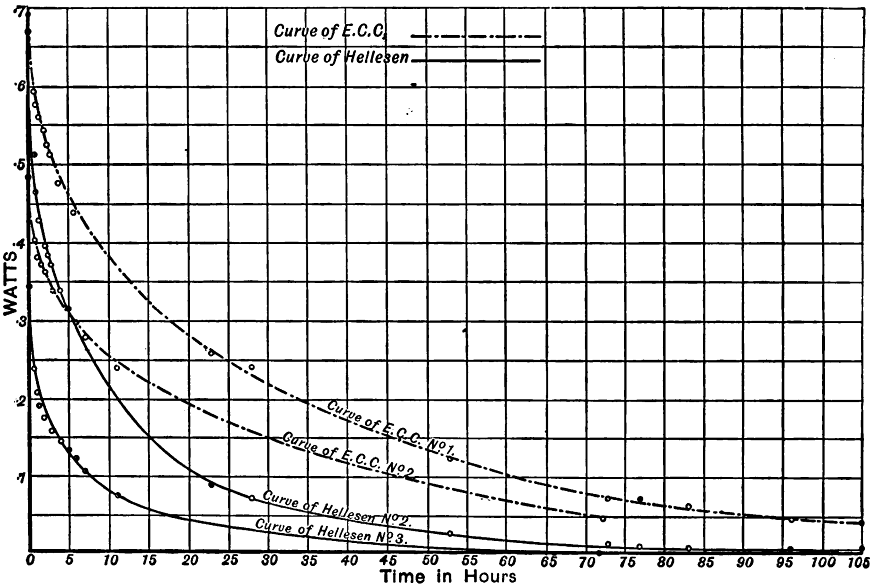
Table showing E.M.F., P.D., Resistance, and Output.

CELL.	E.M.F. VOLTS.	POTENTIAL DIFFERENCE. VOLTS. Initial.	POTENTIAL DIFFERENCE. VOLTS. Final.	RESISTANCE. OHMS. Internal Approx.	RESISTANCE. OHMS. External.	OUTPUT. Ampere Hours.	OUTPUT. Watt-Hours.
No. 3 Hellesen,	1·410	1·130	0·120	0·9	3·75	7·55	3·18
No. 2 E.C.C.,	1·464	1·346	0·448	0·38	3·75	14·69	11·93

The following are a number of the results showing the current and the potential, with the watts calculated therefrom:—

TIME IN MINUTES.	HELLESEN. P. D. Volts.	HELLESEN. Amperes.	HELLESEN. Watts.	E.C.C. P. D. Volts.	E.C.C. Amperes.	E.C.C. Watts.
0	1·130	0·302	0·341	1·346	0·356	0·479
5	1·044	0·274	0·286	1·308	0·344	0·450
10	1·012	0·265	0·270	1·284	0·338	0·433
20	0·978	0·256	0·250	1·256	0·330	0·414
40	0·930	0 243	0·226	1·226	0·321	0·394
60	0·888	0·234	0·207	1·202	0·315	0·378
90	0·856	0·223	0·191	1·186	0·309	0·367
120	0·826	0·208	0·172	1·176	0·306	0·360
160	0·796	0·204	0·162	1·156	0·302	0·349
200	0·764	0·201	0·153	1·142	0·294	0·336
240	0·746	0·197	0·147	1·130	0·285	0·322
280	0·726	0·191	0·139	1·110	0·282	0·312
340	0·696	0·182	0·127	1·086	0·275	0·299
400	0·660	0·174	0·115	1·050	0·267	0·281
HOURS. 11	0·548	0·145	0·079	0·956	0 246	0·235
23	0·314	0·124	0·039	0·794	0·245	0·195
72	0·120	0·034	0·004	0·448	0·108	0·048

Output Curves (No. 5).



The ordinates of these curves represent the power in Watts available in the external circuit of each cell at any time as given by the abscissæ.

(Tests taken during January, 1893.)

An exactly similar test was made on a set of larger cells—namely, a Hellesen No. 2 and an E.C.C. No. 1, for a longer period of 105 hours *(see Curves No 5)*:—

Table showing E.M.F., P.D., Resistance, and Output.

Cell.	Initial E.M.F. Volts.	Potential Difference. Volts.		Resistance. Ohms.		Output.	
		Initial.	Final.	Internal Approx.	External.	Ampere-Hours.	Watt-Hours.
No. 2 Hellesen,	1·363	1·224	0·086	0·25	2·75	15·35	7·81
No. 1 E.C.C.,	1·388	1·256	0·312	0·24	2·75	27·67	18·24

The following are a number of the results :—

TIME IN MINUTES.	HELLESEN.			E.C.C.		
	P.D. Volts.	Amperes.	Watts.	P.D. Volts.	Amperes.	Watts.
0	1·224	0·545	0·667	1·256	0·551	0·692
5	1·146	0·506	0·580	1·216	0·529	0·644
30	1·072	0·476	0·510	1·170	0·508	0·594
120	0·950	0·418	0·397	1·114	0·481	0·536
180	0·918	0·401	0·368	1·088	0·467	0·508
240	0·878	0·383	0·338	1·066	0·444	0·473
300	0·856	0·372	0·319	1·036	0·430	0·445
360	0·824	0·360	0·296	1·004	0·418	0·420
HOURS. 23	0·448	0·199	0·089	0·780	0·328	0·256
33	0·360	0·160	0·058	0·706	0·300	0·229
49	0·266	0·115	0·030	0·546	0·230	0·127
59	0·208	0·095	0·012	0·482	0·203	0·098
77	0·152	0·077	0·010	0·408	0·175	0·071
83	0·140	0·067	0·009	0·382	0·167	0·063
96	0·094	0·044	0·0042	0·326	0·140	0·046
105	0·086	0·041	0·0038	0·312	0·135	0·042

Percentage Polarisation (Test No. 6).

This test was made to determine the effects produced upon the electro-motive force of the cells by polarisation after discharging for a short time.

Two new cells were taken, a No. 3 Hellesen and a No. 2 E.C.C. The true E.M.F. of the cells were first determined, and, after closing the circuit for forty-five seconds, the current flowing and the potential difference were simultaneously noted; then, having broken the circuit as quickly as possible, the E.M.F., as reduced by the polarisation set up, was observed. From these data the percentage polarisation was calculated.

The following gives the results of two experiments:—

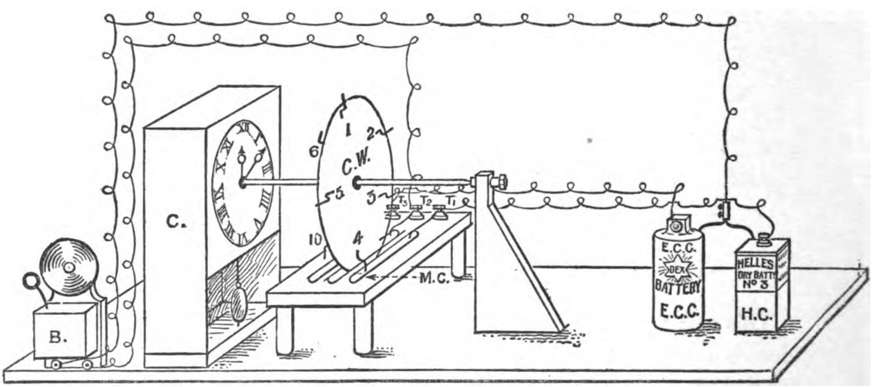
Cell.	E.M.F. Volts.		P. D. Volts.	Current.	Percentage Polarisation.
	Initial.	Polarised.			
No. 3 Hellesen—1st,	1·462	1·370	1·180	0·230	3·9
,, 2nd,	1·408	1·356	1·168	0·227	3·7
No. 2 E.C.C.—1st,	1·474	1·462	1·378	0·230	0·81
,, 2nd,	1·472	1·460	1·374	0·227	0·81

The great difference in the polarisation of these cells accounts in a large measure for their different behaviour and efficiency.

Bell Ringing Tests.

(Taken by Forbes W. Bruce in December, 1892.)

Two dry cells, a No. 2 E.C.C. and a No. 3 Hellesen, were tried in the following way, in order to ascertain which of them would ring a bell longer:—



General Diagram of Apparatus for Bell Ringing Test.

Index to Parts.

E.C.C.	represents	Electric Construction Co. cell.
H.C.	,,	Hellesen cell.
$T_1T_2T_3$	,,	Terminals.
M.C.	,,	Mercury cups.
C.W.	represents	Contact wheel.
1, 2, 3, etc.,	,,	Contact points.
C	,,	Clock.
B	,,	Bell.

The two cells were alternately placed in circuit with a trembling bell, for six minutes at a time, by means of a clock and mercury contacts, as shown in the accompanying drawing and index to parts; in other words, each cell had alternately six minutes' work of ringing the bell, and six minutes' rest. After the clock had gone 230 hours 40 minutes, the Hellesen cell failed to ring the bell. It had done so for 115 hours 20 minutes, with a corresponding time of rest. The E.C.C. continued to ring the same bell, under identically the same conditions, for 498 hours 20 minutes from commencement, or 249 hours 10 minutes' work, with a corresponding number of hours' rest. Thus the E.C.C. cell rang the bell for 135 hours 50 minutes longer than the Hellesen. Every twenty-four hours the position of the cells was reversed. This was done in case there should be a slightly greater resistance in the one circuit than in the other.

The following table of sizes, weights, voltages, and hours will serve to show the conditions under which No. 2 E.C.C., and the corresponding size No. 3 Hellesen, were tested:—

CELL.	WEIGHT.	E.M.F. IN VOLTS.		Hours of Ringing Bell.
		Initial.	Final.	
No. 3 Hellesen, - -	1 lb. 10·4 oz.	1·45	·75	115 h. 20 m.
No. 2 E.C.C., - - -	1 lb. 14·6 oz.	1·48	not taken.	249 h. 10 m.

EFFICIENCY OF THE DRY CELLS TREATED AS SECONDARY CELLS.

(Taken by Mr. J. Fred. Nielson in January and February, 1893.)

Four new cells were experimented upon—namely, two of No. 2 E.C.C., each 1·92 lbs. in weight, and two of No. 3 Hellesen, each 1·67 lbs. (with outside cover).

The cells were numbered as follows:—

Two E.C.C. cells, - - - -	A and B.
Two Hellesen cells, - - -	C and D.

The cells were short-circuited by connecting the negative pole of each to its own positive terminal, and were left thus for 44 hours. By this means the cells were practically exhausted. They

were then connected up in series, and charged with a current of 1·6 ampere for 22 hours. The potential difference between the positive terminal of the first and the negative terminal of the last, or fourth cell, varied, but was on an average about 13 volts. Tests were made of the potential difference at the terminals of each cell at frequent intervals whilst charging.

The mean potential difference during charging, and the approximate number of watt-hours given to each cell, were as follows:—

		Potential Difference.	Watt-hours.
E.C.C.,	A,	2·77 volts,	97·0
	B,	*4·52 ,,	*159·0
Hellesen,	C,	2·85 ,,	100·0
	D,	2·82 ,,	99·0

Discharging Cells A and C through a House Bell.

Cells A and C were tried as to their ability to ring the electric bell in exactly the same way as has been already explained in this paper. The number of hours during which each cell was able to ring the bell, alternately, every six minutes, was :—

For the Hellesen,	66 hours.
For the E.C.C.,	176 ,,

so that the total number of hours during which each cell was in action was :—

Hellesen,	33 hours.
E.C.C.,	88 ,,

Test for Discharge in Ampere-hours, and Output in Watt-hours.

A test, commenced 100 hours after charging, was made with the remaining two cells, B and D, in order to find the ampere-hours, and the output in watt-hours, of each cell discharging through the same known external resistance of 2·2 ohms :—

	Hellesen (No. D),	E.C.C. (No. B).
Electro-motive force, in volts,	1·362	1·534
Internal resistance, in ohms,	2·6 (approx.).	3·2 (approx.).
External resistance, in ohms,	2·2	2·2

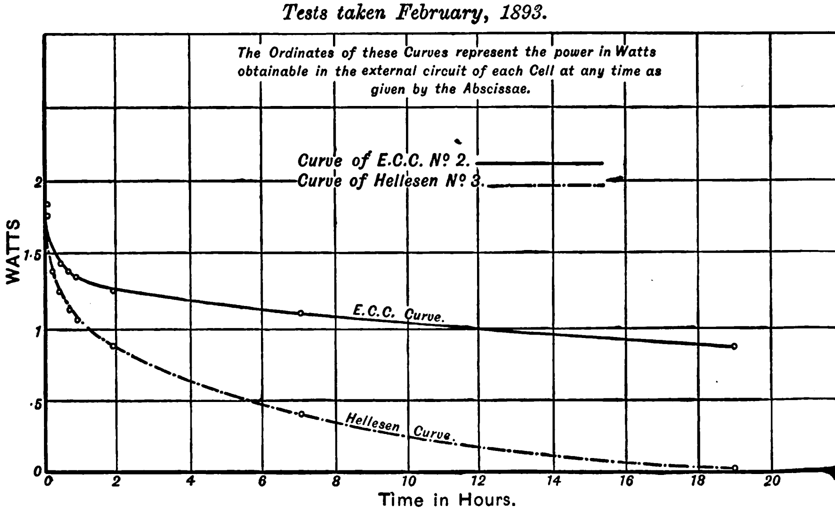
The tests could not be completed, owing to an unavoidable interruption in the carrying out of the experiment, but the following Table and curves (No. 6) show the results :—

* The resistance of this cell was abnormally great, and a large proportion of the power expended must have been uselessly lost in generating heat.

TIME. Minutes.	HELLESEN.			E.C.C.		
	P.D. Volts.	Amperes.	Watts	P.D. Volts.	Amperes.	Watts.
0	·714	·246	·1756	·726	·252	·1829
5	·658	·226	·1487	·684	·226	·1546
10	·632	·216	·1366	·680	·220	·1496
25	·600	·206	·1236	·650	·218	·1417
40	·574	·196	·1126	·634	·216	·1370
55	·556	·190	·1056	·630	·210	·1323
70	·540	·184	·0994	·628	·208	·1306
85	·524	·180	·0943	·622	·206	·1281
100	·516	·176	·0908	·620	·204	·1265
115	·504	·172	·0867	·618	·200	·1236
145	·498	·168	·0837	·616	·196	·1208
Hours. 7	·334	·116	·0387	·608	·184	·1119
19	·096	·034	·0033	·526	·164	·0863

OUTPUT CURVES AS STORAGE CELLS (No. 6).

Tests taken February, 1893.



After having subjected the various cells to such hard work, they were examined externally and internally to see wherein they showed weakness. It was observed that the zinc containing-vessels of both the E.C.C. and the Hellesen cells were pitted internally; and in the case of those most severely worked, the zinc containing-vessels were completely eaten through in places. This defect has been noticed by other electricians, more especially in the case of the E.C.C. cells, since the Hellesen zincs are not only much thicker, but are covered with sawdust and a millboard case. Does this not point to the necessity for the use of thicker and purer zinc casings? Another defect, which was troublesome with both kinds of cells, arose from the breaking of the connection to the zinc containing-vessel. This was chiefly due to its being a solid copper wire. In many cases we had to solder on an insulated flexible conductor, so as to admit of the cells being freely manipulated. Nevertheless, these cells are much handier for laboratory work than any other kind which I have previously tried.

Finally, I have to thank my day-class laboratory assistants, Messrs. Gray and Morrison, and the various students whose names are mentioned in this paper, for the great interest and skill which they exhibited in preparing and in taking the various tests, and I have also to thank Dr. Henderson for kindly getting the cells analysed in his chemical laboratory.

P.S.—Since this paper was written, I have received from Messrs. Siemens Brothers & Co., Limited, a pamphlet, with tables and curves of recent tests made by their electricians, at their Woolwich laboratory, on improved Hellesen cells, which show slightly higher results than those obtained in my laboratory. Consequently, in fairness to the firm, I herewith reproduce their Tables I. and II., with their remarks. Seeing that their results were higher than those obtained in my laboratory, I had the only possible source of error investigated—namely, the E.M.F. of the "Fleming" standard cell. The standard was set up, as before, with pure zinc and copper sulphate, of the densities of 1·4 and 1·1 respectively, and every precaution was taken to ensure accurate results. When compared with three standard "Clark" cells, the mean of the several determinations gave the E.M.F. of the "Fleming" standard, at 15° C., as 1·077 volts. This would alter all the E.M.F. and P.D. results in the ratio of 1·072 to 1·077, or increase them by ·47 per cent.

Table I. shows the decrease of potential difference at the terminals of the cells, when closed through an external resistance of 5 ohms for 1 hour, and the recovery of E.M.F. on opening the circuit, as observed in the first of five consecutive tests.

TABLE I.

Time of Closing.	DECREASE OF P.D. AT TERMINALS WHEN CLOSED THROUGH AN EXTERNAL RESISTANCE OF 5 OHMS FOR ONE HOUR.				
	Type 1.	Type 2.	Type 3.	Type 4.	Type 6.
	V.	V.	V.	V.	V.
0 min.	1·470	1·429	1·415	1·405	1·350
2 mins.	1·440	1·399	1·375	1·370	1·250
5 ,,	1·429	1·373	1·341	1·347	1·201
10 ,,	1·405	1·364	1·305	1·315	1·150
15 ,,	1·387	1·336	1·262	1·285	1·115
20 ,,	1·375	1·314	1·253	1·270	1·088
30 ,,	1·365	1·279	1·220	1·240	1·040
60 ,,	1·330	1·222	1·170	1·185	0·980
Time of Opening.	RECOVERY OF E.M.F. ON OPEN CIRCUIT.				
0 min.	1·345	1·249	1·215	1·230	1·080
5 mins.	1·360	1·287	1·240	1·255	1·138
15 ,,	1·375	1·299	1·265	1·265	1·165
30 ,,	1·375	1·314	1·280	1·290	1·185
60 ,,	1·390	1·329	1·300	1·300	1·210
Several days.	1·505	1·460	1·470	1·460	1·445

This test was repeated five times in succession, allowing, however, intervals of rest between each two tests, the cells were then closed continuously through 5 ohms, until the potential difference at the terminals had dropped to about half a volt, whereupon the circuit was opened and the recovery observed.

These results are shown in Table II.

Table II.

Time of Closing.	Decrease of P.D. at Terminals when Closed through an External Resistance of 5 ohms.				
	Type 1.	Type 2.	Type 3.	Type 4.	Type 6.
	v.	v.	v.	v.	v.
0 hour.	1·406	1·338	1·210	1·335	1·000
1 ,,	1·295	1·151	0·996	1·121	0·449
5 hours.	1·230	1·025	0·880	0·965	0·300
1 day.	1·033	0·910	0·595	0·447	—
2 days.	0·951	0·518	0·348	—	—
3 ,,	0·888	0·366	—	—	—
9 ,,	0·476	—	—	—	—
Time of Opening.	**Recovery of E.M.F. on Open Circuit.**				
0 min.	0·495	0·350	0·425	0·470	0·380
5 mins.	0·520	0·375	0·490	0·538	0·655
15 ,,	0·553	0·415	0·535	0·590	0·800
30 ,,	0·600	0·455	0·570	0·630	0·870
60 ,,	0·640	0·520	0·660	0·685	0·940
1 day.	—	0·985	0·995	1·026	1·135
Several days.	1·018	1·071	1·097	1·157	1·323

VIII.—*The Education of the Deaf and (so-called) Dumb.* (Two Papers.) By James Kerr Love, M.D., Aurist to the Institution for the Deaf and Dumb, Langside, Glasgow; and Mr. W. H. Addison, Head Master of the Institution, and Associate of the College of Preceptors.

[Read before the Society, 8th February, 1893.]

I.—DR. LOVE'S PAPER.

Some three hundred and odd years ago, on a May day, two armies stood fronting each other on the slopes of contiguous hills south of the City of Glasgow. Before night the Battle of Langside had been fought, and the cause of religious and civil liberty in Scotland had scored a great victory. It is not now my business to describe the contest at Langside, nor its effects on Scottish History, but rather to make reference to that historic ground for the introduction of the subject of my paper—the Education of the Deaf in Glasgow. The institution for the instruction of those on whom the great calamity of deafness has fallen stands on the hill occupied by one of the opposing armies, the Victoria Infirmary has displaced the other; and one can hardly visit Langside, and think on that day and on this, without fervently hoping that the temper of the times has changed, that our civilisation is being leavened by charity and benevolence, and that the bigotry and oppression which make men fight have for ever fled away. But, if that be too much to hope for, it is not, I am sure, too much to expect that a company of Glasgow men and women will think kindly of, and listen interestedly to a few words spoken on behalf of, the poor children who live in the institution for the education of the deaf and dumb. Gathered in that building are 140 children who have, with few exceptions, never heard a mother's song or the kind word of a father, who are strange to all music, and who must live always under an oppression of loneliness such as never, even for a moment, visits

any hearing mortal. This number does not represent anything like the total amount of deafness in this great community. The Rev. Mr. Henderson, the Secretary to the Glasgow Mission to the Deaf and Dumb, informs me that there are in and around Glasgow and the West of Scotland 600 deaf and dumb adults. To these must be added the children not of school age, and estimated by Mr. Wright, the School Board Officer, at 19. Mr. Wright also informs me that three under school age are known to the Govan School Board. When I add to these 30, being the number under tuition at Greenock and Burnside, we have a total of 813, which represents approximately the number of the deaf and dumb in our midst.

Adult Deaf and Dumb in Glasgow and West of Scotland,	600
Children at Langside Institution, - - - - -	144
Children under school age known to Glasgow School Board, - - - - - - - - - - -	19
Children under school age known to Govan School Board, - - - - - - - - - - -	3
Children being educated under Govan Board, - -	17
Children at other schools Burnside, Greenock, &c., -	30
	813

But let us return to the children at Langside. I have described them as the deaf, and I have done so advisedly. The dumbness is a mere adjunct to the deafness. You call them sometimes the deaf and dumb. They are quite as correctly described as the deaf and stupid, or the blind might similarly be called the blind and stumbling. Without education deaf children are nearly all dumb, and just as universally stupid. With education the stupidity goes, and very often the dumbness too; but deafness remains. It may vary in degree, but it is the one bond that links them all together. That is why they are at Langside, and not in the Board schools. When I speak of the deaf, therefore, I mean those who are too deaf to learn to speak, or, if young, are in great danger of losing any speech they have. I wish I had a more accurate phrase for this deafness. I have tried to invent one, and have used it elsewhere. This is, however, neither the time nor the place to coin new words; so I will continue to talk of the deaf.

The education of the deaf has always presented, and always will present, special difficulties. In earlier and less humane times not much thought was bestowed on the matter. Some peoples

settled it in a very off-hand way, and drowned those born deaf. Amongst the Spartans, Greeks, and Romans, no attempt was made to educate them, or in any way to ameliorate their condition. They were considered a misfortune, and even a disgrace, both to the family and the nation. The problem of their education was never faced, and they perished with less consideration than the brutes. These latter days have been marked by great activity in settling the difficulty. The duty of educating our deaf is never now questioned. We know that most of the deaf can be made useful and intelligent citizens. Tremendous energy has been expended in bringing about this happy result. Rival systems have sprung up for its production, and the question before us is not—whether it is to be done or not, but how we may best do it. On this question debates have been held, congresses have sat, books have been written—and I need not add that over it many people have lost their temper,—and it is not settled yet. The bone of contention is this—Shall we try to make our deaf use articulate speech or not? Shall we give them a system of easy readable signs, natural and artificial, by which they can rapidly communicate with each other, but which hearing people, as a rule, know nothing about, and care less; or shall we try to make their eyes do the duty of ears, picking up from our lips what we say; and by a close imitation of what our mouths and lips do, shall we try to make the muscles of articulation in the deaf produce articulate speech? In other words—Shall we use the oral or the finger language? Now, if I were to rehearse the arguments used by oralists and manualists, I would not reach the special part of my work to-night, and Mr. Addison would not have a hearing at all. Opinions differ as widely as the poles. Many persons hold that the oral system is all a mistake, that the time spent on it is lost time, that all the orally trained find this system inadequate, and that they ultimately turn to the finger language. The other side—the pure oralists—are just as loud in their advocacy of the oral system as the manualists are in its denunciation. Two years ago, Mr. Van Praagh, of the London Oral Association, wrote me as follows:—"Every deaf child can be educated on the oral system except the idiot and the blind."

What I would like to show you is, that both of these statements are wrong; nay, that they must be wrong. I will give you *a priori* reasons for holding that all the deaf cannot be educated properly on any one system. The attempt to train all the deaf

on a simple system shows an utter want of appreciation of the conditions present in deaf-mutism, and this remark applies to all systems, whether manual, oral, or combined.

Bear with me while I put the case of the deaf child before you in two lights—(1) Apart from the deafness; (2) with regard to the deafness.

I. Apart from the Deafness.

When I say apart from the deafness, I do not mean apart from its cause, but without regard to its amount. If the disease which has destroyed hearing has attacked the ear, and it alone; if it be, for instance, a suppuration which has destroyed the drum cavity and emptied it completely of its ossicles, and if no damage has been done to the brain or to the other organs of special sense, you will have a bright, intelligent child, with a keen eye, a perfect vocal apparatus, and endowed with every faculty but speech and hearing. But if the deafness has been caused by some cerebral disease, such as meningitis, you may have dulness and stupidity, approaching to idiocy, quite apart from the loss of hearing, and, in addition, impairment of eyesight, paralysis of the vocal apparatus, and other special complications. Take, again, the case of congenital deafness: in one child the defect may be limited to the ear, in another the brain may be stunted and the centre for hearing defective. The cases are not at all alike. An anatomist, a physiologist, or a pathologist would not compare them. He would contrast them. The absence of hearing, of course, they have in common. But *that* he would regard as accidental, and not at all belonging to the essence of the case. Is there, then, no difference to be noted when we come to teach them? Is it not reasonable to expect that what will present only moderate difficulty to the one will be quite impossible to the other child?

II. Look now at the Deaf Child in the Second Light: How deaf is he?

There are many superstitions about the deaf and dumb. Many persons think them wild, untameable creatures, others look on them as "uncanny," others as generally consumptive, but, perhaps, the grossest and most wide-spread mistake is as to the extent of the deafness. Most people, and, I am sorry to say, most medical men, think that nearly all deaf-mutes are totally deaf. Well, I have examined during the last two years 175 deaf mutes at the Glasgow

Institution, all but 49 of whom were capable of giving perfectly unequivocal answers to my tests; and I found only nine of them totally deaf. "How deaf is he?" is then an important question with regard to the deaf child.

Deafness is a relative term. "All men are insane" and "None is in perfect health." These are general statements, and are literally true. If we could fix an absolute standard of sanity or health, it is probable that no one could be found who entirely conformed to it. When I assert that all men are deaf, I but add another to this list of curious but true sayings. No absolute standard of hearing power can be fixed, and if it could, almost all who were tested would be found to deviate from it in some way or other. But the statement that most men are deaf is true in another and commoner sense. I hold in my hand a watch, the tick of which is heard by a good ear in a quiet room at a distance of 36 inches. Many healthy people under 40, and most over 40, could not hear it at more than 18 or 24 inches. Some slightly harder of hearing lose it at 8 or 12 inches, and, when the watch has to be brought to within 2 inches of the ear, you ask for a front pew in church, and your friends have to repeat half their conversation. One stage further and you cannot hear the watch at all; your friends have to shout to you. You are only hard of hearing, you say; but do you not know that you have crossed a most important line? You have crossed the Rubicon. It is only your past experience that keeps you out of the ranks of the dumb. With this degree of deafness at 5 years of age you must have grown mute, and at 18 months you never would have spoken at all. I wish I could get this picture graven on the hearts of all who have to deal with deafness in children. If all school teachers, all doctors, and, above all, if the parents of the semi-deaf only could see it as I see it, some at least of those who now swell the ranks of the mute would remain in the hearing world. The auditory nerve is like a person with opium poisoning, you must rouse it, shake it, stimulate it, make it work, or it will soon pass to its eternal sleep. If you do not, if you call your child by a move of the hand or speak to him in signs, either because of your carelessness or your ignorance, very soon he will exchange the gift of melodious, articulate speech for a series of finger gymnastics.

These remarks do not apply to all cases of deafness, even of acquired deafness, but they do apply to a class large enough and important enough to warrant the fervour of my pleading.

Deafness, then, is purely relative. It is present in almost every degree in speaking people, and in all the higher degrees among the dumb.

Now as to the children at Langside: none of them heard the watch at all. Only a few heard the instrument, which I now hold in my hand, a Politzer acoumeter, which gives a much louder tick than any watch. The tests applied were this large bell, this tuning fork, and the human voice. The tongue of the bell is attached at the junction of the handle and the metal by a spring, and when a decided shake is given to the bell a single loud note is emitted, which, with a little practice, can be reproduced with great uniformity. The fork was used sounding in the air, and applied to the bones of the skull. In this paper I refer only to its use as an aërial test. The accuracy of the observations was assured by the eyes of the observer being covered, by his counting the strokes, and by the delivery of false or noiseless strokes of the bell. The bell used in the testing could be heard in the vicinity of the Institution at a distance of about 1,000 yards by an ordinary ear. The fork used was a large one, of about 9 inches long, and gave a note caused by 330 vibrations per second. The voice sounds were uttered with the observer's eyes covered, or they were spoken behind his back. Total or stone deafness means absence of hearing for the sounds of the bell or voice, and for the fork sounding in the air:—

Total number tested, ...		175
Disqualified from youth, &c., ...	49	
Heard perfectly, but mute, ...	3	
Remaining, ...		123, classified thus:—

I.	Stone deaf, ...	9
II.	Heard bell or loud voice, ...	81
III.	Heard and distinguished voice, ...	33
		123

Class III. was made up thus:—

20	heard and distinguished vowels.
13	„ „ „ consonants, and words.
33	

14 were quite deaf to bell.
 5 of these heard the fork.
 —
 9 totally deaf aërially.

80 heard the fork aërially.
43 did not hear it.
———
123

Turning again to Class III. :—

Of the 13 semi-deaf—

10	belong to the	recently-admitted (1891-92)	(10 in 75).
3	„ „	previously-admitted	(3 in 100).
—			
13			

Now, out of the 123 children who were old enough to give intelligent and reliable answers, notice—

1. That only 9 were quite deaf, or 7½ per cent. Nothing but experience, or rather experiment, can guide the teacher as to how these should be educated. They have no hearing left. Now and then a bright intelligent child, with a quick eye, may learn lip reading and articulate well, but the majority of these entirely deaf children will do better under the finger method.

2. With regard to the second class, which supplies about two-thirds of our pupils, experiment again must be our guide. Many of them will make good oral pupils.

3. The third class gives us a fourth of our pupils. Every child belonging to this class should be carefully and persistently tried by the oral method, and most of them will do well. Those belonging to this class who hear consonants and some words must have more than mere oral training. They are the true semi-deaf. They can be taught through their ears, and every aid to hearing, everything which will strengthen hearing power and assist the conduction of sound, must be enlisted. This is the acoustic method, or, as it will generally have to be helped by the oral method, it may be more correctly called the oro-acoustic method. The extent to which the help of the oral method may have to be enlisted in the training of the semi-deaf will vary in each case, and the teacher should have a free hand in using and combining the two methods, but there must be no compromise with signs. Finger-spelling must be accounted a deadly sin with the semi-deaf.

This boy [shown] illustrates oro-acoustic training. He repeats Andrew, John, Monday, and other well-defined words, when pronounced behind his back, but often fails at such words as Robert, &c. These latter he pronounces distinctly when they are spoken before his open eyes.

Now, why should this boy's remaining speech and hearing not be used in teaching him. He is a little too deaf to be taught along with hearing children in an ordinary school, but his ears are still the best road to his brain. If he were blind to a similar degree, we would give him lenses to assist him, but we would never think of leaving his remaining vision unused. If he were lame to this extent, he would be provided with crutches. Why, then, is there no corresponding utilisation of the hearing of the semi-deaf? The deafness which has shut him out of the Board schools is only a little greater than that which makes some of the pupils in the Board schools appear stupid and backward. The difference is not in kind, it is only in degree, and not in great degree. And yet the gulf which separates the methods by which the two are educated is enormous. To ignore this boy's hearing, and especially to instruct him even partially on the finger system, is little short of a social crime. And this crime is systematically committed in the Deaf and Dumb Institutions of this country.

I am not here as the advocate of any one system for the education of the deaf as a class. I believe the oral system to be applicable to a large minority of the deaf. I would give every child the chance of succeeding on oral training, but, after a fair trial, varying from six months to two years, I would hand him over frankly and finally to the finger-teachers if he did not promise well.

The finger method must, I think, be used in the education of at least a half of the deaf, perhaps even a larger proportion. Most of the totally deaf, all those with defective eyesight, all those markedly deficient in intelligence, the very few who have defective vocal arrangements, and all who have failed under the oral or oro-acoustic methods, must use the finger method. The heaviest indictment that I have against the finger method is, that under it the semi-deaf get deafer and soon totally dumb. This is a grave and serious assertion, made now, so far as I am aware, for the first time. I shall, therefore, proceed to prove it. Two years ago, when going over the children then in the Glasgow Institution,

I found several quite deaf to all voice-sounds and totally dumb who were reported in the admission schedule to have heard and spoken to some extent on entering the Institution. These schedules are filled up under the supervision of a doctor, and are, I think, usually correct. I could not resist the conclusion that these poor children had degenerated both in hearing power and in speech during their education period. The finger system was practically the only one in use in the Institution before the beginning of 1891. But I have stronger proof that this conclusion is correct. Among the 175 children examined, 75 may be called those recently admitted—that is to say, admitted within the last two years. Of these 75, 10 are semi-deaf. Of the 100 admitted before 1891 only 3 are semi-deaf. The conclusion is inevitable: semi-deaf children trained under the finger system soon become deafer and totally dumb.

I am glad to have Mr. Addison's assurance that under the oral system the semi-deaf do not thus degenerate. My observations of those tested during these two years must be repeated before I can become responsible for any opinion on this point. I am prepared to find much better results amongst the semi-deaf trained by the oral method than when the finger method alone is used. But we want to do more than preserve the hearing in these semi-deaf children. We want to develop it. And it will develop only if the sound be made to reach the ear by the normal channel —the air—and if the source of sound be the loudly and distinctly articulated speech of a good teacher.

The principle which should guide us in selecting a method for the education of the deaf should be this :—Provided fair progress can be attained, that method should be adopted which least departs from the one by which hearing children learn.

Such is the principle which, I think, should guide those who would teach the deaf, and such are the *a priori* reasons for its adoption.

The classification which I have made is based on the amount of hearing present. Another might be made based on the amount of speech present, and this introduces a class not separately represented in the foregoing remarks—the deaf semi-mute—that is to say, children who are practically deaf, but whose remaining speech depends on the recollection of speech learned before the onset of the deafness. Thus the deaf would be subdivided into the true deaf-mute, the semi-deaf, and the deaf semi-mute.

I would fain leave the matter at this point, for Mr. Addison is here to tell you his experience of actual teaching. But I can hardly conclude without quoting from the latest and highest authoritative statement on the education of the deaf—the Royal Commission's Report. I quote only from the recommendations, and only with regard to the points raised in my paper:—

"We recommend that those children possessing some hearing capacity should be carefully and frequently examined by a medical practitioner, so as to test and improve their hearing, pronunciation, and intonation, by mechanical means, such as ear trumpets, &c." (See Par. 620, Sec. 6.)

In spite of this recommendation, I do not think this work is properly done in any country in the world. In Britain it is practically ignored. In America, although no very systematic medical examination has been adopted, the subject of acoustic training has been more extensively studied. And its most earnest advocate, Mr. Gillespie, the Head-Master of the State of Nebraska Institution, writes me in the most confident and encouraging terms about it.

Again, the Commissioners recommend—"That every child who is deaf shall have full opportunity of being educated on the pure oral system. In all schools which receive Government grants, whether conducted on the oral, sign-and-manual, or combined system, all children should be, for the first year at least, instructed on the oral system, and after the first year they should be taught to speak and lip-read on the pure oral system, unless they are physically or mentally disqualified, in which case, with the consent of the parents, they should be either removed from the oral department of the school, or taught elsewhere on the sign-and-manual system in schools recognised by the Education Department." (See Par. 620, Sec. 9.)

The Commissioners further recommend—"That children who have partial hearing or remains of speech should in all cases be educated on the pure oral system. The children should in all schools be classified according to their ability."

The plain English of all this is that we must have two distinct schools for the education of the deaf in Glasgow—one for the pure oral and the oro-acoustic methods, and another for the sign and manual method. The deaf of this great community will never be properly dealt with till this double school system is established, and the man or men by whose energy or money this result is

attained will earn the lasting gratitude of all interested in the unfortunate deaf.

Appendix.

Table showing Occupations of Adult Deaf in Glasgow District.

Artist,	1	Glass decorators,	3
Bakers,	4	Jeweller,	1
Beltmaker,	1	Jewel-case makers,	2
Boilermakers,	6	House joiners,	3
Blacksmiths,	2	Iron workers,	3
Boxmakers,	5	Labourers,	15
Bookfolders,	4	Lamplighters,	2
Brassfinisher,	1	Lithographic artists,	15
Bookbinders,	19	Moulders,	3
Brass engravers,	7	Marblecutters,	2
Brushmakers,	4	Millworkers,	4
Bricklayers,	2	Needlewomen,	8
Butcher,	1	Painters,	2
Cabinetmakers,	2	Purse makers,	2
Chairmaker,	1	Patternmakers,	4
Capmaker,	1	Riveters,	2
Clerk,	1	Saddler,	1
Coopers,	2	Silver engraver,	1
Calenderer,	1	Shoemakers,	6
Caulkers,	3	Ship joiners,	5
Compositors,	5	Tailors,	12
Confectionery worker,	1	Ticket writer,	1
Carpet designers,	5	Tinsmiths,	6
Domestic servants,	3	Umbrella makers,	5
Dyers,	2	Upholsterers,	3
Diesinkers,	2	Weavers,	5
Draughtsmen,	6	Wood carvers,	4
Dressmakers,	10	Wood turner,	1
Fancy-box makers,	5	Washerwomen,	3
Fitters,	6		
Fishing-tackle makers,	2		244
Gardener,	1		
Glass stainers,	2		

(The above is kindly supplied by Mr. Henderson for this paper.)

II.—MR. ADDISON'S PAPER.

The subject which it is my privilege to bring before your notice this evening—namely, the Education of the Deaf and (so-called) Dumb—is one which has lately attracted a considerable

amount of public attention. This is owing, in some degree, to the greater interest taken in all educational matters, but chiefly, I think, to the revival of the oral method in this country, to the battle of systems resulting therefrom, and not a little to the wonderful stories of marvellous results achieved by the new method which, from time to time, have found their way into the sixpenny magazines and other media for the publication of sensational and highly-seasoned literature.

Thus, we were gravely informed by the then Secretary of the American Board of Education, Horace Mann, that in Germany one girl attained to such proficiency in lip-reading that she could converse with a maid-servant in the night after the light was extinguished by simply placing her hand on the chest of her companion; and of another, a boy who could read the lips of another person by placing his hand upon them in the dark.

I shall not attempt to startle you this evening by anything so wonderful as that; my business is not to arouse expectations which are only doomed to disappointment. I wish simply to place before you, in the words of truth and soberness, the main facts in connection with our difficult task of educating the deaf and dumb.

I must ask you, first of all, to dismiss from your minds two very general, but erroneous, notions which exist regarding us and our work. It is commonly supposed that Providence which, for some wise purpose, has denied to these unfortunates the faculty of hearing, has compensated them for this loss by bestowing upon them some special gift, and, in common parlance, made them very sharp—sharper than other folks, people say. This idea is a very great mistake. It will, perhaps, surprise you to be told that they are not only deprived of hearing and consequently of speech, but that many of them suffer in other ways—their vitality being below the average of that of hearing people. Some are deficient in mental power, and even if they could hear they would still be classed as imbecile; some are deficient in the sense of smell; others lack the sense of taste; and many suffer from weak eyes. In the Liverpool School a thorough testing by an eye doctor revealed the fact that the eyesight of about 70 per cent. of the pupils was below the normal standard, four of the pupils being so bad that they were taught to read the Braille type in anticipation of their becoming totally blind, and they were afterwards taught basket-making in the Blind Institution of that city. Graham Bell calculates that there are fourteen and a-half times as many blind persons among

the deaf and dumb in proportion to the population as there are in the community at large, and forty-six times as many idiotic.

There are, of course, many brilliant exceptions to this dark picture, but I think the facts effectually dispose of the notion that the deaf, as a body, are more gifted than people with the normal senses.

I would also ask you to dismiss from your minds the idea which some persons entertain that the instructors of the deaf and dumb are a species of conjurors, who, by some magical art, engraft the tree of knowledge in the minds of these little ones. I can assure you, ladies and gentlemen, that what we are able to accomplish is not achieved by any feats of legerdemain, but is simply the result of downright hard work, patience, and persevering skill, directed towards a definite object. We must know, first of all, exactly what we have got to do, and then keep "pegging away" till our end is achieved; and we must never know what it is to be beaten, even under the most discouraging conditions.

In the short time at my disposal this evening, it will be impossible to enter fully into every part of the subject. I shall (1st) confine myself, therefore, to such an exposition as shall enable you to understand what is the problem with which we, as educators, are confronted; (2nd) I shall give a short historical sketch of what has been done in past times, with a review of the systems in operation at the present day, stating what, in my opinion, is the best course to pursue in a large school like the one at Langside; and (lastly) by means of an exhibition of the attainments of some of the children here present, I hope to show how far we can realise the hopes with which we set out on our task.

First, then, look at the problem before us. Have you ever pictured to yourselves what it really means to be born deaf? Have you ever seriously considered the true import of those short but terrible words, "*Deaf and Dumb?*" I doubt not. Says a deaf-mute himself, "There is nothing in the general outward appearance of deaf and dumb persons to attract the attention and pity of the bustling every-day world, busy as it is with its own affairs, and absorbed in the contemplation of more striking things. Unlike the blind, whose sightless orbs always painfully compel attention, the deaf and dumb appear like ordinary mortals, with all the senses normal; and, having no voice to utter complaint or make known their condition, they pass on their silent way, unheeded and forgotten. The mind, destitute of the means of communication

except the very rudest signs, is shut up in a dreary prison-house; and so the poor mute grows up with all his mental faculties undeveloped; unable to read or converse with his friends, he is a solitary being in the family circle, a hermit in a crowd, a strong, able-bodied man with the mind of a child."

Many comparisons are drawn between the blind and the deaf and dumb, generally in favour of the latter; but it should never be forgotten that the affliction of the blind is chiefly physical, that of the deaf is mental, they being deprived of language, by means of which all the higher and sustained reasoning processes are carried on. The uneducated mute can and does reason in a limited sense, but of the higher processes he is wholly ignorant till education steps in. He has no knowledge of God, or of the Divine attributes, and practically he is a heathen in the midst of a Christian community.

Some may think I exaggerate when I say that the uneducated mute has no knowledge of God, but most teachers who have investigated the subject agree on this point. Alexander Atkinson, a deaf-mute who was educated in the Edinburgh Institution by Mr. Kinniburgh, one of our earliest and best teachers, speaks thus—"Unlike the Indian, who hears God in the wind, or the blind, who are so keenly sensitive to the sublime medium of sound as to infer from it some rude intimation of some superior spirit, I don't recollect anything like it. Whenever my mother took me to church with her, she bade me join my hands, look up, pray, and kneel down. Making me do the same at home on Sundays, she generally pointed her hand towards the sky; and occasionally showing me some large plates in her large family Bible figuring some child in a devout attitude, I may have imagined, faintly, that her prayers were addressed to the sky. I consequently addressed mine. This impression vanished and returned with the occasion, nor do I recollect any ultimate result from the repetition."

Others, again, have thought that people prayed to the sun, moon, and stars, when they saw them kneel down. The notions many of them are reported to have had in regard to natural phenomena are extremely curious. Snow was thought to be an old woman shaking down feathers; that rain was caused by the spouting of an elephant; and so on.

We see, then, that the problem we have to solve in undertaking the education of a deaf and dumb child is twofold;—we have to

give him the means of communication with the world around him, to teach him language; and at the same time we have to develop his mind, to discipline it, and make it a fitting instrument for the fulfilment of its destiny.

And this is no easy task. Many people have an idea that the power to understand and speak the English language is innate, that we are born with the power, and that it comes to us without trouble and without learning; in fact, that, with a deaf child, all we have to do is to teach him to spell a, b, c, on his fingers, or say them with his tongue, and immediately he will have a command of the choicest classical English. No greater mistake can be made. The English language to a deaf and dumb child is a foreign language, and has to be learned by him in the same way as hearing people learn French or German. When he comes to school, no matter what may be his age, he does not know one single word—father, mother, cat, dog, stone, stick, words of the commonest description, are Greek and Latin to him; and to educate even the brightest born mute to a ready use of common colloquial English is a task of great difficulty and the work of many years. A hearing child, in a Board school, will spend years in learning French, and, at the end, find itself unable to understand or be understood by a Frenchman, and no one is surprised, because all can realise the difficulty in their own persons; but a deaf and dumb child, bereft of two senses, is often expected by parents and others to master the greater difficulties of our language in two or three years or even less. Why, the thing is impossible. "Your difficulty is to understand his difficulty," said Dr. Buxton, and no truer words have been spoken on this subject.

The mistakes made by deaf-mutes in their efforts at written composition are oftentimes very amusing, as well as very exasperating to the teacher, but not more so than the attempts of foreigners at mastering our tongue.

The act of dropping a piece of chalk on the floor was rendered by a class of big boys thus—"you floor the chalk"—"you chalk the floor;" "you wiped your forehead" became "you rubbed your brain;" "you knelt on your pocket-handkerchief" was written—"you quaker it with your legs." One boy said "I am a calf," another "I am a cow;" and when expostulated with by the teacher, altered it to "I am a useful cow." And a prominent member of an Institution Committee was considerably surprised one examination day by a boy writing for him on the black-board "you are an ass," the

explanation being that the gentleman in question was the owner of one, and the boy had confounded the verbs "to have" and "to be," a very common mistake with the half-taught deaf and dumb. "Jesus was the father of Joseph and the mother of Mary;" "Adam was the wife of Eve;" "My dear brother, I am your affectionate daughter;" "I to you love best my send," are all examples of the confusion which exists in many a deaf-mute's mind with regard to the Queen's English.

From what I have now said you will be able to form a pretty accurate idea of the difficulties to be met with in training these children. Let us now see what our predecessors did in the matter. The Spartans, as might be expected from their well-known character, took the simplest way of dealing with the problem: they destroyed all deaf children, in common with all other defectives—a heroic remedy that we are not at present likely to imitate.

Lucretius seems to have held similar opinions, for he says—

> "To instruct the deaf, no art could ever reach,
> No care improve them, and no wisdom teach."

Herodotus records a case of a deaf man, son of Crœsus, suddenly recovering his speech through strong emotion, while the first notice we have of a deaf man being instructed in our own country occurs in Bede's "History of the Church of England," published in 733. There we are told that Bishop John of Hexham had cured a deaf and dumb man by blessing him. But the Bishop, as well as making him "put out his tongue and making the sign of the cross upon it, added certain letters by name, and bid him say A, and he said A; and B. and he said B; and when he had said these, he put them into syllables and whole words to be pronounced, and then commanded him to speak long sentences, and so he did; and ceased not all day and night following, so long as he could hold up his head for sleepe." "Here then," says Mr. Arnold, our latest authority, "appears to be a case of deaf-mute instruction in articulation, more or less successful, as early as the year 690."

We find little or no further mention of the subject till the middle of the 16th century, when Pedro Ponce, a Spanish monk, taught two sons of a Castilian nobleman with much success. It is reported that their progress was so rapid under his tuition that in a short time they were able not only to read and write

correctly, but also to answer any questions put to them. One of them, who died at 21, understood Latin and Italian, and was learning Greek before his departure.

Ponce's successor, Jean Pablo Bonet, published a work entitled "The Reduction of Letters and the Art of Teaching the Deaf and Dumb to read," in which he records his methods as consisting of "artificial pronunciation, the manual alphabet, writing, and gestures, or the language of signs."

The accounts of the success of these teachers is supposed to have travelled to England through the visit of Charles I. to Spain; and John Bulwer, in the year 1648, "exhibited the philosophical verity of that subtil art, which may enable one with an observant eye to hear what any man speaks by moving of his lips, proving that a man born deaf may hear the sound of words with his eye."

John Wallis, a professor of mathematics at Oxford, also wrote on teaching articulation, while about the same time was published at Amsterdam a book entitled "De Loquela," by Amman, which probably was the book from which Heinicke, the founder of the German system, obtained many of his ideas. Wallis, besides writing on articulation, had more extended notions of teaching the deaf and dumb, for he also made use in his instructions of such actions and gestures as have a natural signification. He also showed that letters or writing might be at once associated with our conceptions without the intervention of sounds, a principle which forms the basis of the school of De l'Epee and modern teachers of the silent method, though the same truth had indeed been anticipated by the Italian philosopher, Jerome Cardan.

No general application of these methods to the education of the deaf generally seems to have been attempted till towards the close of the last century. Then it was that the Abbé de l'Epee in France, and Heinicke in Germany instituted those methods of instruction known respectively as the French and German systems, and by the rivalry which they caused did contribute not a little to the rousing of the public interest in the subject, and thereby benefiting the cause of the mute.

Charles Michel de l'Epee was born at Versailles in 1712. He took orders and became a Catholic priest, and in the course of his vocation, having discovered two deaf and dumb girls growing up in ignorance, his heart was filled with pity at their desolate condition, and thenceforward his whole life was devoted to the

development of a system of instruction for their benefit. By devoted labour and attention, the expenditure of his own private fortune and contributions from the benevolent and the Government, he was enabled to educate a large number of poor deaf and dumb children, and his success was so great as to attract universal attention. He was invited to London, where he exhibited his two cleverest pupils, and the interest thus aroused being turned to good account, institutions were established over the whole country—London Asylum dating from the close of last century, the Edinburgh Institution from 1810, and its offspring, the Glasgow Institution, from 1819.

The method employed by De l'Epee, wherein the pupils were first taught an elaborate system of artificial signs, by means of which writing was dictated to them, is now little, if ever, used, even by those who call themselves French system teachers. Great modifications were made in it by De l'Epee's successor, the Abbé Sicard.

De l'Epee's great rival, the German Heinicke, was a very different character from the benevolent Frenchman. His object in life seems to have been to make as much money as possible out of his system. Mr. Ackers thus contrasts the characters of the two men—"De l'Epee was frank, open, generous, self-sacrificing; Heinicke, reserved, mysterious, and apparently somewhat avaricious."

Heinicke, however, seems to have had a better grasp of the principles which underlie deaf-mute instruction, and the lines which he laid down for teaching language are now recognised as being more true to nature and more in accordance with the right method of teaching than those of De l'Epee.

And this brings me to the next part of my subject—a few words on systems. The common division is into three, namely:—the French, or, as many now prefer to call it, the silent system; the German, or oral; and the combined, claimed by some as of British origin, and by others as the American system. Though this division is, no doubt, a convenient one for red-hot partisans to swear by, it is to some extent a misleading one. There are innumerable gradations in vogue;—each system as practised in the different schools imperceptibly shades off into the other, according to the idiosyncrasy of the director; and there are schools called silent-system schools where fewer signs are used than in some of those called oral, and so on.

The French system is generally defined as that which trains the pupil to write on the black-board or slate, to spell on the fingers by the single or double alphabet, and gives instruction in the ordinary branches of education by means of spelling and signs.

The German or oral system professes to dispense with all artificial signs, and also natural ones, after the early stage of instruction is past; it tries to teach the pupil to speak and lip-read, and he is expected to gain all his knowledge of language directly through speech—written words not being presented to him till after he can speak and lip-read them. I say this system professes to dispense with all signs; but if any person can show me a deaf child who does not use some signs, I confess I shall feel astonished, as in the course of a somewhat long experience I have never met with any who did not use signs to some extent.

Thirdly, we have the much-abused combined system, which was the one used generally in this country. The advocates of this method, acknowledging the great importance of "speech for the deaf," but at the same time, unwilling to deprive them of the great help which signs afford, endeavoured to combine the advantages of both the extreme rival systems, while avoiding their weak points. Unfortunately they tried to teach speech as a mere accomplishment—that is to say, they devoted the greater part of the school hours to fingering and signing, and expected their pupils to master the gigantic difficulties of articulate English in the brief space of an hour or half-hour per day, or even less. It is almost needless to say that they failed in most cases in teaching their pupils to speak with any degree of fluency, though they turned out many good scholars in other respects.

Having thus reviewed the different methods according to current notions, it remains for us to ascertain what method or methods are most suitable for the circumstances of a school like our own. At the risk of being tedious, I must again ask you to consider what is our object when we commence the education of deaf children. As I said before, it is twofold—we have to give them the means of communication with hearing people, and we have also to give them the information necessary to guide their conduct in after life. Now, what is the means by which people communicate their thoughts to one another? It is language—language which is of two kinds, spoken and written. I am asked—Can the children who come to our school learn to speak intelligibly? In my opinion, the result of over twenty years of actual work in the

school-room, combined with reading of all the literature I could lay hold of, and observations made in many schools in Britain and on the Continent, I say that some can and some cannot. You will immediately ask what percentage are able to speak intelligibly. Well, I think that is impossible to answer at present, for the simple reason that the ability of the children varies with each batch we admit. Some years we get in a good set, bright, active, and intelligent; at other times we receive a batch who turn out dull, heavy, and stupid; and the proportion varies from year to year.

These considerations have led me hitherto to favour a system which has been called the dual system. Each child who enters the school is first tried on the oral system, as recommended by the late Royal Commission, and, if found suitable, is kept at oral training throughout his whole school course; but if it is found impossible to teach him intelligible speech, he is placed in a silent-system class, and taught written language only. The children of the two classes mix out of school, and all use finger-spelling and signs in communicating to one another. As this has been urged as an objection to our method—and does, no doubt, to some extent injure the speech and lip-reading,—it has been lately proposed to establish a small supplementary oral school, where a full and fair trial could be given to the pure oral method under test conditions. This scheme has been carried out recently at Philadelphia, and is said to give satisfactory results.

The establishment of a similar school in Glasgow would be a contribution to the vexed question of systems worthy of the Second City of the Empire, which should aspire to lead rather than follow in matters educational, as well as in municipal and commercial affairs.

Before finishing, I should like to say a few words with regard to the prospects of the deaf after they leave school. Many people ask me what we do with them, and seem surprised to find that they are able to do anything for themselves, or to earn their own living. There seems to be a notion that there is something "uncanny" about the deaf and dumb—that we keep a menagerie of wild animals who have to be tamed; and we often hear people exclaim, in tones of wonder, "they look intelligent." It may surprise you to hear how *very* intelligent some of them are, and with what success they engage in the various pursuits of life.

The majority of those who leave our schools, belonging, as they

do, to the artisan class, engage in the various mechanical trades, and are preferred by some masters to hearing-and-speaking workpeople. Some draw very well, and attain good positions as engravers, lithographers, &c. In Liverpool, one deaf-mute friend of mine makes a good living as an enlarger of photographs; he also acts as an assistant-master in the School of Art there, and is much liked and respected by his hearing and speaking pupils.

Several mutes have obtained medals in the national competition at South Kensington, and only last year one of our own pupils obtained a prize there for modelling in clay. In London there is a deaf sculptor who is patronised by the Prince of Wales, while several deaf painters exhibit at the Royal Academy.

In America there are two or three deaf clergymen, regularly ordained, who preach to their fellows; and there is one deaf-mute in Church of England Orders.

Some years ago I had the pleasure of an interview with a deaf gentleman from Norway, who is employed in the Government Audit Office at Christiania. Though stone-deaf, he knows Latin, French, and German, besides his own native language, and can write English as fluently as a native with all his senses.

Mr. B. St. John Ackers, who has made a thorough investigation of the subject, both in England and on the Continent, says—"In Vienna we saw a fancy-leather merchant who employed seventy men under him, whose premises the Emperor and Empress of Austria visited before the great Vienna Exhibition, who could not only speak the language of his country fluently, but also a little English; who had visited England and other countries, was a practical horticulturist, and altogether an agreeable, intelligent, wealthy man—wealthy through his own educated talents and industry."

Again Mr. Ackers says—"We saw a dressmaker who had the leading business in one of the smaller German capitals. She was rather shy of talking about herself at our first interview. This came to the knowledge of her lover, who begged we would pay his betrothed another visit, which we did, escorted by him. The meeting was most amusing. He took her roundly to task for having appeared to so little advantage in the morning; and after some lively sparring, rattled off between them just as though both, instead of one, had been hearing persons, we chimed in, and had a long and very pleasant conversation with the deaf dressmaker. She assured us, and this was confirmed by inquiries we made,

that in following her occupation the only means of communication between herself and those who employed her were articulation and lip-reading; she never had recourse to writing; finger-talking and signs she did not understand. A brighter, happier, and more contented woman than this dressmaker no hearing person could have been."

I could give numberless instances like these of deaf-mutes prospering and making their way in the world, but I think enough has been said to demonstrate that the time and money spent on our institutions and schools are not thrown away, but bear a rich harvest in the social and intellectual improvement of our pupils. We have many trials to bear, and many disappointments to put up with, in our work. Some pupils turn out badly, and some have a weakness of intellect joined to their want of hearing, which prevents them making the progress we could wish; but, on the whole, there is much to sustain and encourage us in our efforts to ameliorate the condition of this unfortunate class of the community.

I trust that those of you who are here to-night will carry away with you an enlarged idea of the capabilities of the deaf and dumb as a class, and should you ever become acquainted with any of them, I hope you will show your sympathy for them, by talking to them, and doing what little acts of kindness you can to alleviate what, at best, is a very forlorn and desolate condition. By so doing you will have the reward of an approving conscience, and the hearty thanks of a class who are extremely sensitive to, and grateful for, any kindness shown to them.

IX.—*Memoir of the late Dr. Robert Grant, F.R.S., Regius Professor of Astronomy in the University, and a former President of the Philosophical Society.* By Professor WILLIAM JACK, LL.D.

[Read before the Society, 5th April, 1893.]

DR. ROBERT GRANT was a native of Grantown, in Strathspey. He was born in 1814, and received the elements of his education in an endowed school—established by the Earl of Seafield for the district of which he was the proprietor—which was intended to provide a preparatory training for the Scottish Universities. Dr. Grant began Latin at nine, and was making rapid progress in this and other branches, when, at the age of 13, a serious illness, lasting six years, interrupted his work. His health at 19 still prevented his return to school, but he embarked with enthusiasm on a course of self-instruction. One of the determining incidents in his life was his friendship with the Rev. Mr. Fraser, of Colvend, in Kirkcudbrightshire, who was then a student, and who inspired him with the love of mathematics. He mastered his Euclid, the elements of plane and spherical trigonometry, and Bonnycastle's "Algebra," a book then much in use. After a few months of solitary study, his elder brother, Alexander, on a visit home from London, brought him a copy of Ramsay's edition of Hutton's "Course of Mathematics," which had just appeared. The book introduced him to a wider range of mathematical work. "Lardner's Cyclopædia" was then being published, and two of the volumes—Dr. Lardner's own, on "Mechanics," and Sir John Herschel's "Astronomy," fascinated him, and he used to date from their perusal his strong inclination to the studies of rational mechanics and physical astronomy. At the same time he began Greek, and made himself acquainted with Xenophon and the Iliad, as well as with Herodotus, Thucydides, and some of the poets.

In 1835, the return of Halley's Comet to the perihelion gave a decided impulse to his astronomical studies. He used to tell how he had been looking for it through several days of broken weather, till one night in October it cleared up, and the comet

was there. He called his father to the door, and the old man, who perfectly remembered the great comet of 1811, assured him that it was a genuine comet. He also remembered seeing the planet Venus during the greatest obscuration of the sun in the annular eclipse of 1836. Thus he continued his studies, procuring from time to time the new mathematical books he heard about from Cambridge, and taking them as companions in his solitary walks. Before he closed his life in the north, when his health was re-established, he took a short course in the University of Aberdeen, but it was in lonely rambles, in woods, and under the open sky, that he completed the substantial education of his youth.

He soon gravitated to London, where he spent four years as book-keeper to his brother. But his heart was probably more in his studies than in the office books. Before leaving Grantown he had carefully read the greater part of Newton's "Principia," with Wright's "Commentaries," and he had conceived the idea of writing a history of physical astronomy. To this purpose the solitary young man bent the energies of his mind. In London he read Airy's "Tracts," Pratt's "Mechanical Philosophy," and Pontecoulant's "Système du Monde." With the same end in view he proceeded to Paris, where he supported himself by giving lessons in English, and spent his time in the library of the Institute studying the great French writers in astronomy, and in attending Arago's lectures on astronomy at the Observatory. He was present at the inaugural lecture which Leverrier gave on his appointment as Professor at the Sorbonne, after the discovery of the planet Neptune. He spent over two years in Paris.

Shortly after his return to London, he entered into an engagement with Mr. Baldwin, who was then republishing the "Library of Useful Knowledge," to write a book on the "History of Physical Astronomy." It began in numbers, the first of which appeared in the summer of 1848. Mr. Woodfall, the printer, who was a partner of Baldwin, and a descendant of the famous Woodfall of the "Junius Letters," being struck with some of the early numbers, brought them under the notice of Captain Manners, R.N., Secretary of the Royal Astronomical Society, of De Morgan, and of several other members. The result was an introduction to Captain Manners, and the library of the Society was placed at Mr. Grant's disposal. After the ninth number appeared, this form of publication was abandoned, and the whole work was published finally in 1852. It received a cordial

welcome from the astronomical world. In the autumn of this year Mr. Sheepshanks, the well-known astronomer, who was then editing the "Monthly Notices" of the Royal Astronomical Society, wrote, asking Mr. Grant to take his place. The salary was nominal, but the work introduced him to leading astronomers in this country and elsewhere, and he continued to edit the "Monthly Notices" till 1859. While he was thus engaged, he published, along with Admiral Smyth and Professor Baden Powell, a translation of Arago's "Popular Astronomy" (2 vols., 1855-58), and a volume of "Biographies of Scientific Men," and he gave two courses of lectures on astronomy to large and appreciative audiences at the London Institution, Finsbury Circus. He was a contributor to Knight's "English Cyclopædia" during his residence in London. In 1856 the Royal Astronomical Society awarded him its gold medal, and this was the first occasion on which it had been given for literary services to the science. In presenting it, the President, Mr. Johnson, then Radcliffe Observer at Oxford, said—"Throughout the book no one can fail to be struck with the rare skill, integrity, and discernment the author has displayed in tracing the successive stages of progress, or with the scrupulous care he has taken to assign to each of the great men whom he reviews their proper share in the common labour. Nowhere is this more conspicuous than in the discussion relative to the discovery of the planet Neptune. By a simple narrative of facts he has placed the history of that great event in so clear and so true a light that I believe I am not wrong in saying he has gained an author's highest praise under such circumstances—the approval of both the eminent persons concerned." This testimony is still applicable, and, in the judgment of competent experts, the only defect of Dr. Grant's "History of Physical Astronomy" is that it is not supplemented by the history of the advances made in the subject during the forty years that have elapsed since its publication. I trust I may be permitted to express a hope, which I am sure will be shared by others who were privileged to hear the introductory lecture of his successor on March 7th, "On the History of Gravitational Astronomy during the last forty years," that Dr. Becker may perhaps some time fill up the outlines of that lecture, and bring the "History of Physical Astronomy" down to the present date.

While he was in London Dr. Grant spent a year, on the invitation of the late Astronomer-Royal, in acquiring practical

familiarity with observational work at the Royal Observatory, Greenwich, and thus completed his preparation for the appointment of Professor of Astronomy and Director of the Observatory at Glasgow, on the death of Dr. Nichol in 1859. His first connection with Glasgow seems to have been made at the meeting of the British Association in 1855, when a committee was appointed, on the suggestion of Professor Henry, the well-known American savant, to form a catalogue of the scientific memoirs hitherto published. It consisted at first of Professor Stokes, Mr. Cayley, and Mr. Grant. Professor De Morgan was subsequently added. The committee met often in Cayley's rooms in London, and they laid the result of their work before the next annual meeting. The Association did not see its way to proceed further, but the Royal Society took up the matter afterwards, and the result was the eight magnificent volumes cataloguing the scientific memoirs which have appeared since the beginning of the century. In the preface honourable reference is made to the labours of the British Association Committee.

Shortly after his appointment to Glasgow Dr. Grant went to Spain to observe the total eclipse of the sun, which took place on 18th July, 1860. He had the satisfaction of seeing a portion of the chromosphere, the envelope of red matter surrounding the sun, the existence of which he had first previously demonstrated in the winter of 1850-51 by a discussion of the observations of previous eclipses.

In 1861 Dr. Grant proposed to the Town Council of Glasgow that certain public clocks in the city should be electrically controlled by a current from the Observatory. A committee was appointed, but the progress made was slow, and in the meantime an attempt was made to forestall the work by firing a time-gun in Glasgow from the Edinburgh Observatory. Professor Grant resisted this attempt in the most strenuous manner; the invaders were ultimately routed, and the system of clock-controlling which still holds its ground here was definitely established. In 1863 a valuable addition was made to the resources of the Observatory by the purchase of the nine-inch Ochtertyre equatorially-mounted refracting telescope, which was made as the result of subscriptions obtained by Professor Grant from a few gentlemen, chiefly merchants in Glasgow. This instrument was employed for several years in observations of comets and minor planets, and in measures of double stars. The results of the observations of

comets and minor planets were published in two papers in the *Astronomische Nachrichten.* In 1865 Professor Grant made an arrangement with the Astronomer-Royal for ascertaining the difference of longitude between Greenwich and Glasgow by means of a series of electric signals transmitted from Greenwich to Glasgow and from Glasgow to Greenwich. Glasgow, Edinburgh, and Cambridge are the only Observatories in the United Kingdom which have had their longitudes relatively to Greenwich determined by a similar interchange of electric signals.

In 1867 Dr. Grant forwarded two letters to the French Academy on the alleged Pascal-Newton correspondence and relative documents, a short notice of which I may permit myself to give as an indication of the thoroughness of Dr. Grant's work. The famous French mathematician, Chasles, had sent the Academy two letters purporting to be from Pascal to Robert Boyle, dated 1652—thirty-five years before the publication of Newton's "Principia"—in which the law of universal gravitation, according to the inverse square of the distance, was expressly stated, and in the latter of which certain numbers were given, as if casually, confirming the law. These first letters were followed from time to time, in the course of the latter half of 1867, by repeated batches of notes and letters taken from a collection in the possession of M. Chasles, each produced successively in turn to strengthen the inference as to the authenticity of its predecessors. The production of these notes and letters interested and excited the whole scientific world. M. Fangère, the editor of Pascal's works, after having been permitted by M. Chasles to examine a number of them, unhesitatingly pronounced them forgeries on the evidence of the handwriting. M. Chasles declined to say how he came by them, but steadily persisted in his belief in their genuineness. In answer to objections by Sir David Brewster, who had never seen any letters from Pascal to Newton in his search through Newton's whole correspondence while engaged in writing his life, M. Chasles published a new set of letters showing the relations between the two men, and, among others, one professing to be written to Newton, who was then a boy of 11½ years. In a previous letter from Pascal to Boyle, the former had expressed his curiosity and surprise at having received from a young student three papers—one on the infinitesimal calculus, another on the system of vortices, and a third on the equilibrium of liquids and on gravity. In response to these remarkable efforts,

Pascal was induced to send the boy a collection of original papers received from Descartes, and various problems which had formerly been the object of his own pre-occupations, "so as to exercise your genius." He begged the boy's opinion of them, but he warned him not to fatigue his young imagination.

Like the rest of the scientific world, Dr. Grant read these documents in the *Comptes Rendus.* With admirable and instinctive sagacity, he fastened on the numbers which appeared in the so-called Pascal papers. These stated—

1. The relative masses of the Sun, Jupiter, Saturn, and the Earth, as

$$1, \quad \frac{1}{1{,}067}, \quad \frac{1}{3{,}021}, \quad \text{and} \quad \frac{1}{169{,}282};$$

2. The relative densities of the same bodies—

$$100, \quad 94\tfrac{1}{2}, \quad 67, \quad \text{and} \quad 400;$$

3. The comparative intensity of gravity at the surface of these bodies—

$$10{,}000, \quad 943, \quad 529, \quad 435.$$

Dr. Grant asked how these numbers could have been arrived at from the data that were available to Pascal. No note or letter was adduced showing them to have been actually communicated to Newton, but they all appeared in the third edition of the "Principia," published 64 years after Pascal's death. Dr. Grant pointed out that they found their place there as a consequence of observations and measurements made by Cassini, Pound, and Bradley, many years later. He pointed out that in the first edition of the "Principia," published 25 years after Pascal's death, an entirely different series of numbers appeared, founded on the best observations then accessible to Newton. These made the masses—

$$1, \quad \frac{1}{1{,}100}, \quad \frac{1}{2{,}350}, \quad \frac{1}{28{,}700};$$

the densities—

$$100, \quad 76, \quad 60, \quad 387;$$

and the gravitation at the surfaces of the bodies—

$$10{,}000, \quad 804\tfrac{1}{2}, \quad 536, \quad 805\tfrac{1}{2}.$$

He explained in detail the observational elements that were necessary to make the calculations. He showed that the

results in the first edition of the "Principia" were the necessary inferences from all the latest observations of that time, and those in the third edition were equally necessary corrections of these inferences from the most recent date. The numbers in the so-called Pascal notes were merely numbers, with no explanation as to how they had been arrived at. They were in three separate series of figures, each *identical* with those in the "Principia" of 1726, each differing completely from those in the first edition of 1687. Only two conclusions were possible :—(1) That the Pascal forger had, unfortunately for himself, taken the numbers from the edition of the "Principia" of 1726; or (2) that the numbers had been forwarded to Newton, who was only twenty when Pascal died, only 11½ when Pascal's alleged first letter to him was written, and certainly under 11 when he was said first to have written to Pascal. According to this theory, Newton must have, in 1687, deliberately suppressed these numbers, either culpably, or because at the time of the publication of his first edition he was induced, by his data, to replace them by other numbers. But in 1726 a miracle must have happened, or a crime. The newest data had worked out the identical numbers which Pascal was alleged to have known, and supposed to have communicated to Newton some time before his death. If Newton—then 84 years of age—knew that these results of his latest calculations were the genuine Pascal numbers of some 70 years previously, which he had deliberately rejected 40 years before, it was treason to Pascal's memory not to mention the astounding fact. If he forgot that in 1687 he had weighed these very numbers, and deliberately rejected them, it was little short of a miracle. There was no way out of the dilemma, and the whole series of documents, in fact, collapsed decisively through Dr. Grant's intervention. Where they came from, when they were forged, why they were palmed off on M. Chasles, of whose good faith there appears to be no doubt, were questions interesting only to detectives. But Dr. Grant's argument proved conclusively that no such documents ever had passed under Newton's eyes, and the inevitable conclusion—inevitable to all the rest of the world but M. Chasles—was that somebody copied the numbers, which had never appeared before, from the edition of the "Principia" published in 1726, and inserted them, by a fatal indiscretion, in the letters and notes which he was anxious to palm off as the work of the great Frenchman who died in 1662.

In 1868 an important addition was made to the work of the Observatory at Glasgow by the establishment of a system of meteorological observations in connection with the Meteorological Office in London. These were all made with self-recording instruments, and they had to undergo careful reductions, after which they were forwarded to London, and published with the results of the other affiliated observatories. This scheme of the meteorological office came to a close in 1883; but it is well known that Dr. Grant made strenuous and successful efforts to have the observations continued here through subscriptions obtained from the Clyde Trust and the Town Council. In 1868, 1869, and 1870, he delivered three courses of lectures on Astronomy at the Royal Institution, London. He was elected President of this Society in 1870, and in the three succeeding years he delivered a series of lectures to ladies in connection with the University.

It was in 1883 that his catalogue of the mean places of 6,415 stars, calculated for the epoch 1870, founded on observations from 1860-81, made its appearance. It was published at the expense of the Government, and was justly described by the late Astronomer-Royal as the work of a lifetime. "The Glasgow star places," says Professor Copeland, in the obituary notice which appeared in *Nature* on 10th November last, "were at once looked on with confidence by the numerous observers of comets and minor planets. One point connected with the catalogue deserves special mention—that although the observations from which it is derived extend over a period of 21 years, the work appeared within two years of the close of the series. This promptitude excites the greater admiration when we learn that, exclusive of Professor Grant's personal share in the work, no less than thirteen young assistants at various times took part in the observations, and two others in the computations. Many of these personal changes, each of which brought its extra quota of work to Professor Grant, were, no doubt, in some measure due to the smallness of the allowance provided for assistance—namely, £100 per annum. Professor Grant, however, was the last man to waste his energies in complaints, and all that he says in his preface is that in recent years all this work has pressed very heavily on the slender resources of the Observatory." In the introduction Professor Grant has determined the proper motions of a hundred stars which, with a few exceptions, had hitherto escaped detection. It was a gigantic piece of work, which would have been accepted

with gratitude from any fully-equipped observatory, having a complete staff of well-paid assistants. It was unprecedented as the contribution of an observatory so poorly supplied as that of Glasgow. It was only, indeed, at the cost of many personal sacrifices that it was successfully completed.

On the last day of his life Dr. Grant read the last proof-sheet of the continuation of this great work. It has been published since, and contains the positions of 2,156 stars, and a careful investigation of the proper motions of about 200 telescopic stars. This continuation was published at his own expense, but part of the cost of printing and distributing it has since been repaid to his family by the liberality of the Bellahouston Trustees. Dr. Grant was deprived the satisfaction of seeing in print some very important results of his labours at the Observatory—namely, a series of valuable micrometric observations of 400 double stars, made with the Ochtertyre refractor; and a memoir on the climate of Glasgow and neighbourhood, based on twenty years' observations, from 1868 to 1887. In his last year he had contemplated retirement from his University duties, but he had not actually retired. A few hours before his death Robert Grant put the finishing touch to a work which had occupied him all through his career in Glasgow. He has left behind him the record of a single-hearted and life-long devotion to his noble science.

X.—*Exploration of the Amazonian Provinces of Central Peru.*

By Alexander Ross, F.R.G.S., London and Ceylon.

[Read before the Society, 5th April, 1893.]

(Plate V.—Map of Central Peru.)

In the paper which I have the honour of submitting to you this evening, I have tried to put together facts which would not only be interesting from a purely commercial point of view but also from that of the general public. I therefore propose—first, to give an account of my journeys in that country, still so little known; its scenery and the people met with; and to show you pictures of them from photographs, mostly taken by myself: those of the railways, however, being courteously lent me by the manager of the Peruvian Corporation. In the second place, I will touch upon the commercial future of the country as to its mineral resources and adaptability for planting.

These journeys were undertaken by invitation of the Peruvian Corporation of London, who were desirous that experts in tropical agriculture should inspect and select territory in Central Peru which they had the right of acquiring. The party consisted of Mr. Arthur Sinclair, and, as practical botanist, Mr. P. D. G. Clark, Assistant at the Royal Botanic Gardens in Peradeniya, near Kandy, Ceylon, and myself. The area of Peru extends to 500,000 square miles, or as much as England, France, Spain, and Portugal put together. Our travels in this immense area of country, however, were confined to the central portions of the interior, and extended from Chicla (the late terminus of the railway from Lima, the line now being open to Oroya), in the direction of the Amazon basin, as far as the rapids of the Rio Perené on the east, the towns of Cerro de Pasco and Huanuco on the north, to Jauja, Huancayo, Comas, and Andamarca, on the south and south-east. We also visited the western coast north of Callao.

First Journey.

On the 7th of July, 1891, all preparations for our journey in the interior being complete, we left Lima by the Central Railway of Peru. For the first twenty miles the line passes through a fertile valley, where sugar-cane, cotton, &c., are extensively cultivated. Soon, however, the hills close in on the valley, their steep, bare slopes seeming scarcely to afford room for the railway, which had to be cut along their rocky sides. Still higher, though the mountains seem to meet in front of the line, there are frequent nooks, and these, as well as every slope, have been carefully terraced and cultivated, though apparently well nigh inaccessible.

The first day's journey extends to Matucana, 57 miles from Lima, and situated at an altitude of 7,788 feet. Here travellers occasionally remain for a day or two to accustom themselves to the rarefied air of the mountains, while the atmosphere being very dry, with a cool, bracing climate, the place is a favourite resort of invalids from the coast.

By the courtesy of the Sub-Prefect, who provided us with guides and mules, we were enabled, during our stay, to visit the country above the town, where we were greatly astonished to find the bare, rocky appearance of the hills give way to a surface rich with vegetation. Here were scattered broadcast heliotrope, calceolaria, lupin, tansy, dockweed, ageratum, and many other familiar flowering plants, while from the garden of an Indian farmer, at whose house we rested, 11,000 feet above the sea, were brought specimens of most of our English favourites—roses, sweetwilliam, marigolds, fuchsia, &c. Dotted here and there were huts of Chola Indians, the highlanders of the interior. Fields of ripening wheat and barley alternated with plots of potatoes and alfafa, growing in pockets of richest soil in the terraced sides and hollows of these great mountains, all bearing witness to the skill and industry of the earlier inhabitants and to the thrifty habits of their descendants.

After leaving Matucana the line passes through a very wild rugged country to Chicla, the terminus of the railway. Chicla is 87 miles from Callao, and is situated 12,215 feet above the sea. The vicinity of the station affords an ever-varying scene of industry; droves of llamas, mules, and donkeys, are constantly arriving with mineral, agricultural, and other produce from the interior, to which, in turn, they carry back merchandise, machinery, &c., from the railway.

At this altitude cultivation ceases, yet along the sheltered slopes and hollows near Oroya numerous flocks of sheep and some herds of cattle find abundant pasturage.

The bridle road crosses the summit of the pass at 16,200 feet, and close to this is the Galera Tunnel, 1,270 yards long, and the highest in the world, piercing the range at a height of 15,700 feet. The eastern watershed begins from the summit just mentioned, and a gradual descent is made upon Oroya, situated at 12,257 feet, and upon a river of the same name. At present Oroya is a mere collection of huts, but has an important future, as the junction for several feeding lines of projected railway opening up the Sierra and the Amazon basin.

Our first explorations were directed to the district in which some of the affluents of the Amazon take their rise. We therefore made for the convent of San Luis de Shuaro, *via* Tarma and Chanchamayo; our object being to consult and arrange for guides, &c., with the Superior of the Franciscans, who have for years worked the missions in the interior of Peru. The road, which in parts is extremely rough, from Oroya to Tarma ascends rapidly until it crosses the summit of the second range of the Andes. It then descends by gradients of great steepness into a long and narrow valley, which gradually widens till we again arrive among the terraced, cultivated hillsides and rich fields of the Peruvian highlanders—the Chola Indians, as they are called.

In our descent we encountered the first harvesting operations which we had seen—the Cholas thrashing out their grain by a method common in many parts of the Eastern world. A large quantity of cut barley had been collected, and, being spread out on the threshing-floor, was trodden out by a dozen sturdy cattle, which, though smaller, much resemble our Highland breed in this country. They were driven by laughing peasants—men, women, and children,—who were most heartily enjoying the fun of keeping at work and in their place the younger cattle, which would "bolt" from the circle whenever the chance occurred.

On reaching Tarma we met the Prefect, who was on his way to Lima, escorted by a numerous suite. To him I presented our letters. We were warmly welcomed, and, in the usual effusive way, as is the custom of the Peruvians, had the resources of the district placed at our disposal. Tarma is 18 miles from Oroya; but so steep and rugged is the path that it took us about six hours to ride. By desire of the Prefect we were escorted to our

hotel by the Sub-Prefect and the Governor. The town of Tarma is situated at an altitude of 9,800 feet, in a basin surrounded by towering hills, which are everywhere terraced and cultivated. To it the surrounding districts send their produce—wheat, barley, coffee, coca, rum, &c.—for sale, and also for transport to the mining districts, the railway, and Lima. The town seems only to need the telegraph, the railway, and improved postal communication, to become one of the largest and most thriving in Peru. It possesses a dry and bracing climate, in which those suffering from pulmonary complaints derive much benefit.

Some of the town officials must take life very easily. I had occasion to send one day to the post-office, but was told that the postmaster had gone to a cock-fight, and would not return till evening, till which time the post-office was closed.

The Chola Indians of Peru are a short, thick-set, and muscular people. The men are sallow-complexioned; their clothes made of the thick woollen stuff of the country, generally sewn and patched till the original is unrecognisable, a hat of greyish soft felt, and shoes consisting simply of a piece of hide tied round the foot and ankle, with thick worsted stockings rolled over the trouser-legs, and tied below the knee. The women, who do the bulk of the work, are broad-chested, stumpy, and muscular, with dark rosy complexions and straight black hair, which they wear divided into two plaits, which hang down the back.

These people are an active and industrious race, though much given to rum drinking. The liquor is distilled from sugar-cane and is about 22 to 40 degrees over proof. The women give this (and I have witnessed it) to their babies, and, as a consequence, and from other causes, infant mortality is very high. The dress of the women consists of a straw hat, like a Panama hat, a shawl, and a gown of blue serge, shoes, but no stockings.

Both men and women persistently wear the dress described, whether in the low tropical country or in the Puno or higher ranges of the Cordillera, at an altitude of 15,000 feet. Many of these Cholas possess one or more donkeys. The husband, wrapped in his poncho—a square plaid of vicuña wool, with a hole in the middle through which the head passes, the plaid hanging loosely from the shoulders,— rides and smokes, while his "better-half" trudges alongside, constantly spinning from a bunch of wool held in the left hand, by means of a spindle hanging in front, and twirled by

the fingers. On her back she carries the "family hope," or, failing that, the carcase of a sheep or pig, or perhaps a sack of potatoes, by the sale of which they are enabled to renew their stock of rum and what necessaries they may require to purchase.

Having rested several days at Tarma, we set out for the Montaña (the name given to the forest regions extending eastward from the Andean slope into the great Amazonian basin), by a wide but rough road, passing the town of Acobamba, where we saw tanning and hand-loom weaving. Of vegetation, after leaving Tarma, there is none, excepting cacti (which seem to be cultivated by the road for their fruit and as fences), unless in the valley extending between these two towns, which is very highly cultivated, and beyond Acobamba, where the lower slopes of the hills are again terraced, and grain is grown.

About twelve miles from Tarma, near the village of Palca, the road was enlivened by a profusion of broom in full flower. Presently we reached the counterpart of the grand and rocky country on the western slope of the Andes. Though not unaccustomed to dangerous bridle tracks in tropical mountain ranges, we felt by no means comfortable as our mules picked their way along the very edge of some beetling precipice, or tried to pass, at some dangerous point, a drove of donkeys laden with small barrels or kegs of rum, which they were conveying to the towns or mines on the hills. But this trying road will soon be a thing of the past, as a new one is being rapidly pushed on, which will undoubtedly lead to the opening of through communication between the navigable waters of the Amazon and the Pacific at Callao. The present road gradually descends to about 4,000 feet, and, emerging from a narrow gorge through fields of sugar-cane, reaches the Chanchamayo Valley.

Here we were most hospitably entertained by the owner of a large sugar estate, M. Monier by name, a French gentleman. We ourselves were housed, while the mules were put out to graze—a rather unfortunate circumstance for them, as on sallying out next morning we noticed that several of them were bleeding freely from wounds inflicted by the vampire bats. The Chanchamayo River is crossed by a long wire suspension bridge, wide enough for a mule to pass, but extremely shaky. However, we all crossed in safety; but at a similar bridge further on, over the River Tulumayo, the muleteer stupidly allowed two of the pack mules to try and cross together, with the result that the one

carrying the two air-tight boxes, in which were all my papers, books, camera, and dry plates, tumbled into the river. The poor beast was swept down several hundred yards and drowned, while the boxes were got out some hours afterwards, battered out of shape, the locks intact, but the contents in a state of pulp. The camera came to pieces in my hands, as did a new roll-holder containing films, with some valuable negatives, while many of the packets of dry plates had burst, exposing their contents to the light. Hence the want of better photographs than I have to illustrate this lecture.

La Merced, a thriving little place, is situated in lat. 11° 6′ 63″ S., and long. 75° 17′ 36″ W., at 2,400 feet above the sea, 198 miles from Lima, and is the centre of an Italian colony. There are two hotels, some stores and shops, and 300 to 400 inhabitants. The climate is humid, and during the day very warm; but it is exceedingly healthy, there being a marked absence of malaria. Among the inhabitants are Chinese, Italians, and Peruvians, engaged chiefly in trade and agriculture. Twenty years ago this district was the scene of a busy planting industry, which has since greatly fallen off, owing to scarcity of labour, expensive transport, and imperfect communication with the towns and markets of the hills and coast. It is destined shortly to emerge from its present state of semi-neglect, for through it will probably be opened communication between the Pacific and the Atlantic, bringing within the reach of civilisation what is now a waste of trackless forest. The present road follows the left bank of the River Chanchamayo, which is navigable for balsas, or flat-bottomed boats, to near La Merced, then crosses the rapid mountain streams Rios Blanco and Colorado, as far as Buen Pastor, near Port Wertheman.

At the former place, the residence of a thriving Chinaman, we had luncheon cooked by his Indian wife, who was surrounded by a numerous family of pretty, pale-faced children. The head of the house was a Roman Catholic, and had been twenty years in Peru. He stated that he never had a wish to, nor ever would, return to his native land.

Shortly after leaving Buen Pastor, we came upon a family of Campas Indians (the so-called savage Indians of the territory beyond). They were living in a little hut upon a recently cleared plot, planted with Indian corn. The family consisted of four—father, mother, grown-up daughter, and a son. As soon as they

caught sight of us, they, the daughter not excepted, rushed towards us demanding rum, and were bitterly disappointed when told we had none with us.

Soon afterwards we came to the River Paucartambo, which near this point joins the Chanchamayo. The united streams take the name of the Perené, a fine broad river whose course we were to follow while exploring the adjacent lands.

Before dark we reached the Convent of San Luis de Shuaro, where we had been expected, and were warmly welcomed by the Superior and Brothers, two of whom had that day arrived from the River Ucayalli, *via* the River Pachetea. An empty room was assigned to us in which to lay our camp beds and other effects, while an attempt to put up our own tent, more in the way of practice than for anything else, was met by a hint that it would give offence, the Fathers wishing us to accept, while there, such hospitality as they could offer.

Besides the usual buildings and offices of a religious house, there is a school-room, in which some Indian children are taught. In the chapel, service was held morning and evening, when it was a pleasure to us to listen to the responses and sweet singing by these children of the forest, led, while also accompanying on the harmonium, by the good Padre himself. Heavy rain detained us here for three days, but at last, accompanied by Padre Sala, chief of the mission, and Padre Carlos from the Ucayalli, we set out upon our wanderings in the wilds, having sent the pack mules on ahead. It had been arranged that we were to follow the track then being opened towards the River Pichis, but it proved so difficult for our laden mules that we soon got ahead of them. However, we kept on, with the idea that our guides were taking us to the residence of a Campas Indian chief on the banks of the River Perené.

Crossing the Paucartambo, about two miles from the convent, we entered the dense forest, and struggled along a track almost impassable from its narrowness, deep mud, and absence in many parts of any sort of gradient. Our pace was not more than a mile an hour, but shortly after dark we came out upon a small pajonal, or grassy glade. Here, under a roof which seemed about to fall, but which the Chunchos, or savage Indians, keep always thatched, and, but for the broken supports, in good condition, we found the tomb of him who called himself Atahualpa, not the great Inca who was strangled in 1533, but an Indian whose real

name was Juan Santos, who headed a successful insurrection against the Spaniards in 1740. The manner and date of his death are unknown.

In darkness, turning our tired mules loose, we had supper off tinned sardines and tea. Sheltered by the tomb, which had been overturned, and in which were some of the bones of the dead chief, we spent the night lying on our saddle cloths and sleeping in our clothes and waterproofs. Next morning we got off at about 8 a.m., and at 1 p.m. we had a really good warm meal at the camp of the engineers who were engaged in tracing out the new road. About 4 p.m. we came in sight of the Perené, and, from an altitude* of 5,300 feet, had a magnificent view of the lovely river, stretching far away between its wooded banks. Almost perpendicularly below us lay the lonely hut of the chief whom we were going to visit, and, impatient to arrive at our night's lodging, we pushed on, the way being a track only, down the face of the mountain, so steep that we had to unload the mules, turn them loose, and leave them and our saddles, &c., on the hillside. About 7 p.m. we reached the hut, situated on the river's bank at an altitude of 1,700 feet. On arriving we were met and welcomed by a most extraordinary-looking Indian, who was called the doctor, and one or two others, rude and unkempt-looking savages. Under a roof of leaves, on a bed made of sticks, lay stretched the owner of the place, worn out with fever.

Having again committed the fatal mistake of getting too far ahead of our luggage, we had to repeat our experience of the preceding night, and go wet and hungry to our beds, which were made of a few freshly-cut palm leaves spread on the ground. The following morning, as neither food nor anything else had arrived, I set out, accompanied by Mr. Clark, up that fearful mountain in search of our mules, and to get some quinine. We wandered that day in the forest, got two doses of quinine from the road engineers; and meeting a man going with supplies to the encampment, we purchased all he could give us, namely, a tin of lobsters, one pound of cheese, and a bottle of Pisco. On this Mr. Clark and I supped; we lit a fire and lay on a heap of grass, being disturbed at 2 a.m.

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* The instruments sent out by the Peruvian Corporation having been delayed, all altitudes given on this *first* journey are those given me by Mr. Clark, whose aneroid, registering up to 20,000 feet altitude, continued in working order after my own, marking only to 12,000 feet, had gone wrong on our ascending beyond that limit.—A.R.

by a heavy thunder-shower. Having my waterproof, however, I lay there, and at 6 a.m. we set out, scarcely able to move, in quest of our mules. At 9 a.m. we met them, opened a box, swallowed each a tin of Brand's chicken essence, cut a piece off some ham, and set out for the Perené again, taking with us something to eat for that night.

To descend the river, balsas, or flat-bottomed boats, were necessary, and, as only one or two small ones were available, others had to be made, which took some days, owing to the timber having to be cut in the forest. These balsas are small rafts made of the *Ochrome piscatoria*, a tree of light spongy wood, found growing in abundance in the vicinity of the river. They consist each of seven logs of about 15 to 18 feet in length by 5 to 7 inches diameter at thick end. These are bolted together horizontally with long pegs of extremely hard palm wood, also found in abundance in the forest. The thin ends of the logs are placed together to make the "bow" of the balsas narrow, and, as the under side is bevelled off at the points, the raft skims over the water instead of pushing through it. On top of the seven logs are secured also by these pegs, at fixed distances, three or four cross blocks of the same wood; whilst on the top of these again are placed two poles, of about 2 inches thick, of the *Ochrome*. These run parallel to the logs underneath, and being, with their own diameter, about 5 inches above the raft, they form a sort of platform upon which passengers may sit, and secure rails by which to hold on to when rushing the various rapids. On this platform, too, any baggage is secured and carried. The balsas are guided by two boatmen, both having paddles. One stands at either end, and uses the paddle to guide or propel as required.

While waiting near the rapids, we made various excursions with a view to discovering the suitability of the district for tropical agriculture. The vegetation is extremely varied, and the soil of great richness. During our stay we were visited frequently by Campas Indians of the lower Paugoa districts, who, leaving their balsas at this place, cross the hills to, and return from, the Cerro de la Sal with their supply of salt. Nearly all of them, on noticing us, came to shake hands, exchanging with us the salutation, "Añyee," signifying "friend." These Indians are dark, copper-coloured, of middle stature, muscular, and wiry; many, too, are not unpleasant-looking, though the features of some plainly indicate that one should beware of them. They are greedy,

inquisitive, and laugh continually at everything or nothing. Raimondi says, "They are very hostile, and no friendly relations can be entered into with them." Mr. Clements Markham describes them as "a barbarously cruel tribe of untameable savages."

Thanks to the introduction of Padre Sala to Kinchoquiri, one of their chiefs, who had numerous friends along the banks of the river, we suffered no molestation, and I found, from my experience of them, though at times morose, sullen, suspicious, and shy, they are not without intelligence and humour, nor would it, in my opinion, be difficult, with tact, to civilise and make them useful. Kinchoquiri had resided near La Merced, and was, therefore, not altogether ignorant of the outer world. On one occasion, however, to be described further on, we were in great danger from this tribe. Their weapons are bows and arrows—the latter barbed, occasionally with monkey's teeth, and feathered in a spiral, thus showing an acquaintance with the principle of rifling.

The women wear necklaces of monkeys' teeth, and a cotton tunic like that of the men, but having only short sleeves to above the elbow, where they hang birds' wings, skins, bones, &c. Their hair is worn hanging over the forehead and cut just above the eyes; this fashion, however, is not unknown among tribes of a much higher civilisation in the old world. Both men and women paint their faces—some with the black juice of a jungle fruit, some red with annatto.

The features of the country, as seen from the Metraro pajonal, or "hill of natural grass," are, near the river bank, steep-wooded slopes rising to about 500 feet; thence, up to 4,000 feet, the land undulates till, at about 6,000 feet, precipices jut out, and beyond in the distance the Cordillera shuts in the view. North and east the country is one long stretch of easy sloping undulations, broken here and there by crests and ridges, all clothed with dense forest.

On the left bank of the Perené, beginning from the river Eñeno, near the junction with which is situated the residence of Kinchoquiri, the range rises in an easy slope until the stream Uberiqui is reached. From this eastwards extends the Pampa Hermosa, or "beautiful tableland," stretching away towards the River Ucayalli. The right bank is bounded by mountains running down to the river, with rich and sheltered valleys between them. These are drained by the Pichana, Quimiri, and Ipuji streams. The prevailing rock formation along the Perené is disintegrated slate, an indication of an auriferous country.

The Perené itself is a river of considerable volume, varying in width from 60 to 150 yards at the narrowest parts, where the banks are high, to 200 or 300 yards, where these are low and receding. In the latter reaches, the stream divides into two or more shallow channels, where generally there is a considerable dip or fall, and in which the speed over the shallow, pebbly bottom is seldom under seven knots per hour. Elsewhere, excepting in a few deep, still pools, the current is not much under four knots. In depth it varies from a foot or 18 inches over the shallows referred to, and 2 or 3 to 6, 10, and 15 feet near its bank and midstream, where frequently no bottom was touched even at the latter depth. The streams falling into the Perené on the north are the Eñeno, about 12 miles in a direct line from Port Wertheman, of no great length or volume, indicating the close proximity of the watershed above. At its confluence with the main stream it is about 20 feet wide and 3 to 4 in depth, but above it is wider and much shallower. A short distance below this river we landed and tasted the water coming in a small stream from underneath a rock, and found it quite salt, indicating, probably, another salt mine not very far off.

Next, about five miles, also in a direct line further down, is the Uberiqui, a stream of greater volume; while further on are two much smaller streams, which were all but dry. On the south, five miles further, is the Pichana, which, while draining a wide and deep valley, is larger than either of the others mentioned. At its mouth a sandy delta has accumulated, almost obscuring the stream, which runs into the Perené with considerable velocity. Still further, where the banks of the latter recede some distance, is the Quimiri, a small unimportant rivulet, more noted by us because of our having stayed the night at a Chuncho's, or Indian's, hut, a short way from its mouth. Last of all comes the Ipuji, which, draining a more steep, transverse range of mountains, delivers a considerable volume of water shortly before the cascades are reached.

A little eastward of the Ipuji a mountain range crosses the valley, and it is in cutting a way through this that the Perené formed the series of cascades. Here is an obstacle to navigation; but from what we saw of them we should say there was nothing that engineering skill cannot overcome; and, if further down the difficulties are not immeasurably greater, there exists no reason why, almost at once, or at least simultaneously with the opening

of the Chanchomayo-Tarma road, a way could not be found of connecting the railway system of the western coast with the waters of the Amazon.

We had intended to explore these rapids throughout, but our intention was frustrated by Padre Sala intimating to us that neither he nor the Campas Indians would proceed any further with us, and that we must return forthwith. The reason assigned was that some festival was due at which Padre Sala's presence was imperatively required at the convent; but no doubt there were other causes of which we knew nothing. A great change had come over our guides, who were now morose and sullen. Eventually the Padres, though I had the repeated assurances of Padre Sala that they would not leave us, after gradually drawing ahead of us on the river, left us, taking our food with them.

On the afternoon of August 9th we landed at a Chuncho's hut, and one of our boatmen proceeded across the river ostensibly to procure food. After a long absence he returned, accompanied by 25 men, who were all armed with bows and many arrows. With them our balsa men said we must stay the night. As we were powerless to paddle the heavy balsas against the strong current by ourselves, there was no help for it but to accede to this arrangement. We noticed that our Peruvian servants, contrary to their wont, did not make preparations for spending the night close to us, and, on enquiring, they replied that they were more accustomed to sleeping in the woods. Presently the Indians began a war dance, accompanied by a low monotonous kind of pipe music. Not relishing the aspect of affairs, we made an ostentatious display of our fire-arms, and lay down to pass a very anxious night, but not to sleep. This had a good effect, for though the dance and music were kept up through the night, we were not further molested. During the night the Indians all got drunk on a liquor which they make from the mandioc plant *(Janipha Manihot)*, and were helpless by the morning. At sunrise we packed up, and succeeded in making our people leave early.

We arrived at the mouth of the Eñeno, our starting-point, on August 12th, our men done up, and we ourselves glad of a rest. We rested two days, and then set out for Tarma, where we arrived on August 23rd, *via* Metraro where we found our mules, provisions, and tent. Here we remained a couple of days, and it was at this place, after consideration of our explorations and viewing the surrounding country, that I penned the despatch recommending

the Peruvian Corporation to acquire the two million acres of magnificent country since granted to it, and to which a colony of Italians has recently been sent.

Second Journey.

The next journey undertaken was to Huanuco, on the Rio Huallaga, also one of the great tributaries of the Amazon. To reach it we returned from Tarma to Acobamba, thence turning north-west, through a narrow defile which is highly cultivated, we proceeded nearly as far as Cacas—the point whence it has been suggested the railway from Oroya to Tarma and the Perené districts should leave that to Cerro de Pasco. The head of the valley approaching Cacas presents some wonderful geological features. A stream which flows along cuts deep into the earth, above it lies a great thickness of conglomerate; then, again, there is yellowish, sandy clay, which is itself topped by immense masses of solid rock in bold precipitous outline.

Cacas is a little Sierra town, situated at an elevation of 12,400 feet, upon the border of the Pampa of Junin. The latter is an immense plain, in which the towns of Junin, Carhuamayo, Ninacaca, Pasco, and Cerro de Pasco are situated. At Carhuamayo, the road through the mountain passes to Huancabamba, a distance of 24 leagues; thence 9 leagues to Mayro, the highest navigable point on the River Pachitea, the latitude of which is 10° 55′ N., and the longitude 75° 40′ W. of Greenwich. Cerro de Pasco is a town of from 6,000 to 8,000 inhabitants, all of whom are engaged chiefly in silver mining and trading. It is situated on the Pampa, at an altitude of 14,200 feet, in close proximity to some of the most extensive and richest silver mines known, and which mines have been worked for generations by the Spaniards and Indians. The direction of the plain is from south-east to north-west. Some idea of the wealth of these mines may be formed from the fact that, during the occupation of the Spanish up to 1803, the immense amount, it is stated, of £61,860,320 was realised from their working. Although the industry has greatly fallen off, there still is a large amount of silver produced monthly, which will be very largely augmented when certain measures which are in contemplation, affecting the drainage of the mines, shall have been completed. In the vicinity are also veins of coal, almost at the surface, and in considerable quantity. The coal here varies

some being akin to our own Wallsend, burning freely, full of gas, and leaving a minimum of ash. Other sorts there are which burn more slowly, giving off great heat, but leaving more ashes. The climate is raw and cold, but not unhealthy. Snow, mists, and rain or sleet, are frequent.

Leaving Cerro de Pasco, the road leads almost immediately down a wild and narrow gorge, beside the tiny rivulet whose source (which is a spring) is pointed out just where the descent begins. It is the Huallaga, one of the great affluents of the Amazon. As it descends, the stream speedily increases in volume, tearing and tumbling along its rocky bed almost all the way between mountains, whose sides are so high and precipitous that they barely show landslips, measuring from 100 feet upwards, which have occurred. The mountain ranges on either side trend north and south, are rich in soil, and from 12 miles below Cerro de Pasco begin to be cultivated in the usual terraces. The valley widens at Huarriacca, which is placed at an altitude of 9,550 feet, where there is a warm mineral spring; and near it, in the middle of a small field, a hole, 5 or 6 feet wide at its surface, and sloping to about 3 feet in depth, where we were told birds and reptiles, on crossing, fall dead—the reason no one knew. At this spot we found a blackbird and a mouse, both dead; we were assured snakes also died if they essay to cross this spot. There was no indication of gaseous exhalation. I stood in the place, but experienced no ill effects; indeed, we were told it had none upon human beings. The pit was only about 70 yards—though across a stream—from the warm mineral springs, with which, probably, it has some connection.

The climate of Huarriacca is pleasant and bracing—dry for half the year, but wet from November to April or May. The slopes become loose and dangerous from landslips a few miles on. The prevailing rock is decomposing slate, over which the soil is extremely rich. The valley continues narrow and precipitous till near Ambo, 18 miles farther on, at 7,400 feet altitude, it opens out, and tropical vegetation and crops begin. It was a couple of miles ere reaching this place where we first saw coffee. The whole country is extremely dry, and cultivation is carried on by means of irrigation. The hills above, 2½ miles from Ambo, seem slipping, or partly to have slipped, into the valley beneath in one huge mass. From Ambo northwards the aspect of the country changes. The hills recede somewhat; the valley widens; fields of sugar-

cane, rows of willows, and clumps of the wild pepper trees, among which some pretty villages, their locality marked by church spires, adorn the plain.

Huanuco (altitude 6,125 feet, boiling point 201° bar.) is reached after a delightful ride, a great part of the way lying through an avenue of eucalyptus trees. The town is of considerable size, having numerous stores and shops. Owing, however, to its grass-grown, neglected streets, it presents a sad air of decay. It is situated in an old bed of the Huallaga, on its left bank, at the lower end of the plain, which is sandy and full of water-worn pebbles. On account of the extremely dry climate, vegetation, except cacti, is very scanty, and is only seen where irrigation is possible.

Returning to Cerro de Pasco by the route we had come, we proceeded to Lima, *via* Incapilca, San Blas, Bañios, Casapalca, and Chicla, arriving on 24th September. The plain a great part of the way after leaving Cerro de Pasco is absolutely flat, of immense extent, fringed on the west by a most peculiar rocky formation of the Andean range, resembling in the distance forest trees, but which as we got nearer (though still many miles off) seemed to be huge, perpendicular, laminated rocks, standing upright, as it were, in a bed of snow. Towards the east, and trending southward, the high and undulating range above Carnamayo was partly hidden in a furious drifting snowstorm. The scene was extremely grand, but our admiration was tempered by the cold, and the effects upon some of our people of the sickness brought on by breathing and by exertion in the rarefied air of these great altitudes.

Our first stopping place was Incapilca, 8 leagues from Cerro de Pasco, on the shore of the lagoon of Junin. Our view of this lake was very impressive. It is about 24 miles long by 12 broad, and, as we rode along the shore, the sun suddenly burst out, illuminating the surface of the waters covered with countless waterfowl, while the mountain background was still veiled in drifting snow.

At Bañios are some hot springs, about 126° F. The water contains free sulphide of hydrogen, and a large quantity of salts—sulphates and chlorides. At this place, where we were disturbed during night by an earthquake of some violence, is a prettily situated hamlet at head of a narrow valley, which is enclosed by high, precipitous, rocky mountains, and watered by a river of

considerable size. I shall never forget my ride hence to Chicla, the railway terminus, and end of our second journey. I had to push on ahead, owing to the illness of one of our party, and to make arrangements for conveying him to Lima. Getting away, after securing a sample of the water of the hot springs, all alone along this romantic glen, in which, at starting, on the river banks, we found wild duck and geese (which scarcely took the trouble to waddle out of our way), snipe, and quail, and meeting scarcely any one, I was charmed by the solitude and wild grandeur of the high beetling crags, the snow-capped peaks, and never-ending pale green sward, till, ascending higher and yet higher, to where vegetation ceases, I found myself—at an altitude of almost 17,000 feet, among bare fragments of porphyritic rock—myself and mule, a mere speck on that great hillside, 'neath the still towering rock-girt range of mountains, whose dazzling mantle of spotless snow lent a coolness to the burning rays of the tropic noonday sun. The air was still, and the bleating of sheep in some far off cranny, the jingle of bells worn on llamas toiling with loads towards the summit, came like a strain of home-like music to the ear. The stillness and awe-inspiring solitude of the short stay at the summit; the wild imposing view down and among these dark ravines; the utter nothingness of myself amid these surroundings, have left an impress upon my memory never to be effaced. Alas! my camera had come to grief ere this, and I have no reproduction of the enchanting picture.

THIRD JOURNEY.

On my next journey I was accompanied only by a young American, Mr. Dorsey, from Harvard, sent by his University to collect ethnological and other relics for the World's Fair at Chicago. Mr. Clark ere this had sailed for England, while Mr. Sinclair had gone to recruit on the west coast, after the (to him) trying experiences on the Andes. Our way was directed to the valley in which are situated the towns of Jauja and Huancayo, and to the country to the eastward, towards the Rios Eñé and Perené. Leaving Lima for Chicla and Oroya, evidences of the approach of the rainy season were met with, in sleet and snow in Chicla; and near Galera, where I stayed a night with Mr. Ward, the engineer in charge of the tunnel, the country was all over white with snow. The road taken ascends to and runs along the

Puno, which stretches in rocky country, or extensive, flat, and undulating plains, the whole distance till the first Sierra village, Acolla, the centre of a rich agricultural district, situated at an elevation of 11,800 feet, is reached, and near to which are some Inca ruins. Sheep and cattle are to be seen (but not in large numbers) grazing all along the way. The only habitations are those of a shepherd at Cachicachi, an estancia consisting of a few huts, and of the village of Acolla.

Jauja, a town of some importance, situated at 11,800 feet, possesses one of the finest climates in Peru. Residence in its most salubrious atmosphere is considered an assured cure for pulmonary complaints. Rain falls only between November and April; during the rest of the year there is none. It is situated at the head of a large valley, at the extreme southern end of which, 1,000 feet below, is Huancayo, a fine town of equal importance. Along both sides of this magnificent valley, which is densely populated, and extends about 35 miles in length by from 6 to 10 miles in breadth, there are numerous towns and villages, the inhabitants of which are chiefly engaged in agriculture, but who also work at the mines of the Yauli, Cerro de Pasco, and other districts. The hills around bear evidences of the skill and industry of the Incas of past centuries, in the numerous ruins invariably on their crests, and in their terraced slopes. Everywhere the soil is of a rich chocolate loam, which is readily cut up into ruts, and washed away by the rains where the terraces, through neglect, have been broken down.

The Oroya River debouches upon the plain at Huarripampa, bisecting the valley, and destroying a large extent of country in the vicinity of its course. Huancayo, situated at 10,800 feet altitude, is a town not perhaps so populous as Jauja, but to which more produce is taken for sale at its weekly market, held on Sundays. It is prettily situated, and slightly wooded. Here the broom, growing to about 20 feet high, attains its greatest excellence, and lined the roads, at the time of my visit, with perfumed avenues of golden-tinted blossoms.

Returning to Ocopa, the chief monastery of the Franciscan Friars, I found Padre Sala, my companion on the expedition to the Perené, now in charge as Superior. The following morning we set out towards the Rio Pangoa. A steep ascent for over three hours, through very rough ground, and many small potato fields, took us to the first summit, at 15,000 feet. We followed

the rocky track over extremely rough and undulating country, crossing ridges at 14,500 feet and 15,000 feet, when a rough track begins to zigzag down the face of the ridge, among high, rugged, and precipitous mountains, till the eastern watershed is reached. The descent to Comas is along the course of a stream, which increases in volume as it lengthens towards the town, 24 miles from Ocopa, and situated at 10,400 feet altitude. The country all along the route is cold and bleak, with snow-capped ranges, seeming, from the summits we had passed, to flank and bar the way. Very stunted grass only is produced along this sterile region, and only a few cattle are seen, and no cultivation, till, at about 12,000 feet, small fields of potatoes are here and there encountered. Comas was reached at dark in the company of the Curé, whom we had overtaken on the road, and to whom we had a letter. The village is prettily situated on a high and narrow saddle jutting out between two rivers, but at an altitude of 800 and 900 feet above their rocky beds. The inhabitants, of whom there are about 1,000, follow agricultural pursuits only. They grow potatoes, Indian corn, grain, and alfalfa. Their tools and implements are all of wood. We stayed all night with the Curé, by whom we were hospitably entertained. The following day we set out for Andamarca, distant 36 miles. The country throughout is of the wildest description; the roads are excessively steep, and at many points dangerous.

Ascending and descending from 10,500 to 13,000 and 15,000 feet by roads which, at times, bore no semblance of a track, till, after a long descent, Matapa, at 8,100 feet, is reached; and at Andamarca, at 8,300 feet, in the same wild region (of which it is the chief place), we decide to stop. The country about this latter town is wild in the extreme, the ravines are narrow, and the hillsides steep and almost bare of any vegetation excepting grass.

Returning to Lima by the same route, I arrived there on 9th of November. On the 24th of that month I sailed for England by way of Eten, where I had arranged to visit the hacienda of Señor Pardo, son of a former President of Peru.

There is not much of the Sierra visited by us suited to modern systems of tillage; but in the Montaña there are vast areas at suitable altitudes well adapted for settlement by European immigrants, whilst in the lower parts of the Amazon basin, in a climate more or less unsuited to white labour, immense

tracts await only the introduction of Chinese or the Indian coolie to turn what is now a magnificent forest wilderness into a rich and thriving province. The Central Railway has now been opened to Oroya, an engine having reached it on 10th of January last; and the Chanchamayo road is nearly completed to the lands of the Peruvian Corporation selected by us on the Perené. The immense influence which these will have upon the future of Peru and its progress will soon become apparent. At present, to those who have not seen that country's varied and unlimited mineral resources, its grand forests, its rich soil, and splendid rivers, a full realisation of the future of Peru is a matter of immense difficulty.

I wish now to ask your further attention while I touch upon a few points connected with the climate, natural resources, adaptability for planting, and trade of Peru.

1.—Climate.

Although situated in the tropics, Peru enjoys a great variety of climate, and is very healthy. The sea-coast is almost rainless, and the summer temperature is about 68° to 72°. At an altitude of 10,000 feet above the sea there are, of course, greater variations, the temperature during the day ranging from 70° to 75°, and falling at night to 50°. The atmosphere is very crisp and dry. On the upper tributaries of the Amazon the climate is more humid, but even there malaria is not prevalent.

2.—Natural Resources.

These may be divided into mineral and vegetable. On the coast exist large deposits of chloride and nitrate of soda and petroleum, with shipping ports conveniently adjacent. In the spurs of the Cordilleras are found coal (both bituminous and anthracitic), gold, silver, copper, lead, cinnabar, and numerous other metalliferous minerals. Peru is no exception to the general rule that the more valuable a mineral is the more difficult it is of access.

Concerning soils and vegetation, I can only spare time for the baldest and shortest account, for both soil and vegetation are so varied that I might well take up several evenings in describing them. The prevailing soil in the Montaña, the forest region east

of the Andes, is a deep, rich loam, so that the simplest tillage is ample. On the steep mountain slopes, up to 12,000 feet, we again find deposits of six to eight feet of rich, dark soil. On the great pajonals (seas, as it were, of grass land in the midst of the forest) the soil is a poor clay; but the forest lands themselves seem to be all that could be desired for coffee, cacao, coca, cocoanut, cinchona, cinnamon, cardamons, nutmeg, pepper, rice, rubber, sugar-cane, sago, tea, tobacco, vanilla, &c. In the mountains many of our British garden flowers grow luxuriantly. The ageratum, for instance, so formidable an enemy when coffee was at its best in Ceylon, serves to show a soil suitable for the "fragrant berry." Wheat, barley, and potatoes grow in great perfection at from 8,000 to 10,000 feet, the latter even to 12,000 feet. The alfalfa, our lucerne, grows extensively to 10,000 feet. In the forest, among many other trees, we noticed palms, walnut, satinwood (not the Ceylon variety), besides innumerable orchids, mosses, lichens, &c., testifying to the rainfall.

The land we selected to take up as suitable for coffee, cocoa, &c., lies in the Perené valley, about lat. 11° S., long. 75° W., altitude from 4,300 down to 1,050 above sea level. A breadth of twelve and a-half miles on each side of the Perené would give about one and a-half million acres of inexhaustible fertility, from which suitable land could be selected to produce more coffee than the whole eastern world at present supplies. This land, too, has the great advantage of lying within reasonable distance of both outlets of the valley—that is to say, the railway and the Ucayalli River. The present terminus of the railway is at Oroya, and by this time a good mule road thence to the Rio Perené, has been nearly completed. This would supply a good outlet towards the west. To make a free eastern outlet, it would be necessary, in addition to deepening the channels of some of the minor rapids, to render navigable the cascades of the Perené, about 40 miles below the junction of the Eñeno. This could, doubtless, be done by blasting, or the difficulty could be surmounted by constructing a "portage," about 7 miles in length.

A few more details about the Central Railway may interest you. The line starts from Callao, the port of Lima, and extends to Oroya, 30 miles east of the summit on the Amazonian slope. The gauge is 4 feet 8½ inches, and the maximum gradient is 1 in 25, while the minimum curve has a radius of 130 yards.

The line crosses the top of the pass by the Galera tunnel, 1,274 yards in length, 15,645 feet above the sea, and 108 miles from the coast. The Verrugas viaduct is 575 feet long and 275 feet high, and is built upon the cantilever principle. Passenger and freight trains, both ascending and descending, travel at about ten miles per hour between the summit and the coast. Between the summit and Oroya, however, ordinary rates of speed will be maintained. The fuel employed is the residual oil of petroleum, which comes in tank steamers from the wells of the London and Pacific Petroleum Company at Talera. Its success as fuel has been amply proved.

To revert to the planting question: On the west coast there are extensive sugar estates, on some of which now, alas! on account of the low commercial value of sugar, rum is distilled instead. Where modern machinery and appliances have been introduced, sugar still pays handsomely; but elsewhere the demand for rum is so great, and its manufacture so profitable, that it has now become one of the chief products of these most fertile regions. Rice is also extensively and successfully cultivated. This part of Peru is practically rainless, and resembles the Egyptian desert, alike in its arid aspect and its productiveness under systematic irrigation. Never have I seen sugar-cane so vigorous and lasting as on the hacienda Tuman, where for nearly a week I enjoyed the hospitality of Señor Pardo, a son of the late President Manuel Pardo, to whose family this magnificent property belongs. The Montaña, however — that is to say, the Amazonian district — is destined one day to be of the greatest importance. The accessibility of its rivers, an unrivalled climate, soil of superb richness, and ample rainfall, ensure a future of almost unparalleled prosperity when the energy, capital, and labour, that have been available elsewhere, have found their way to, and seriously undertaken the cultivation of, these extensive regions. There is no product either of the temperate zone or the tropics that cannot be grown at the varying altitudes found along the great slopes of the Eastern Andes and Montaña.

With regard to labour, a most important point, the local supply is altogether insufficient. European labour would be too costly, and, in addition, unsuited for altitudes below 3,000 feet. In my opinion, the docile, active, and intelligent Indian coolie would be far the best form of labourer, or, failing him, the Chinaman; and with an ample supply of Bengalese, Tamils, or Chinese,

and a sound backing of capital, together with the approaching transport facilities, I believe there is no better opening in the world for trained planters than the upper valley of the Amazon.

There is one branch of commerce about which I have up till now said nothing. I refer to wool. Peru possesses a large number of wool-bearing animals—sheep, the vicuña, huanuco, llama, and alpaca. At present, however, the country is very backward from a manufacturing point of view, as may be seen by the fact that it imports yearly about 2,000,000 dollars worth of manufactured woollen goods. Don F. Pezet, from whose paper on Peru I take these remarks, says that the wool of all these animals is of very superior quality, and that he has every reason to believe that, if the raising of the animals were carried on after the manner which obtains on Australian sheep-runs, the success attained there would be repeated in Peru.

There are at present only two important factories of woollen goods in Peru—the one at Lacre, in the Department of Cuzco, belonging to Messrs. Gaemendia & Co.; the other at Lima, belonging to Messrs. Prado & Pena.

Petroleum is another industry which offers a grand field for enterprise; the deposits are enormously rich, and the future of mineral oil as a fuel has advanced greatly since its adoption on the railways in Peru.

I hope, if I have not succeeded in interesting you, that I have at least made it clear that a vast amount of practically unbroken ground in nearly every department of commerce is to be found in Peru. The former wealth and prosperity of the country in the times of the Incas was proverbial, and, although it suffered cruelly under the Spanish domination, since its independence has been declared, Peru is slowly but surely advancing, and to all appearance investors may be promised a safe and rich return for their capital.

I owe my acknowledgments to Mr. Lane, C.E., late of the Central Railway, from whose paper I have quoted particulars relating to railways and minerals.

XI.—*Lord Kelvin's New Electricity Meters.* By ANDREW W. MEIKLE, M.A.

[Read before the Society, 30th November, 1892.]

IN 1887, Lord Kelvin reported to the Society regarding the progress of his work upon electrical measurement, in a paper entitled "A Double Chain of Electrical Measuring Instruments." Since that time much has been done to improve and complete the *chains* then spoken of, and they now form the recognised standards in all parts of the world. The chain of balances has been extended, and now affords a means of accurate measurement from $\frac{1}{100}$th to 10,000 amperes. The chain of electrostatic voltmeters has been made to suit all ranges from $\frac{1}{100}$th of a volt to 150,000 volts. Besides these two types of standard instruments, others have been made to suit the requirements of power and light installations. These are made mostly on the plan of the ampere gauge (Fig. 1), which has actually been constructed to suit all ranges between $\frac{1}{4}$th of an ampere and 15,000 amperes. Some special instruments have been designed, from time to time, to suit various requirements, and I am pleased to be able to show the Society an instrument designed

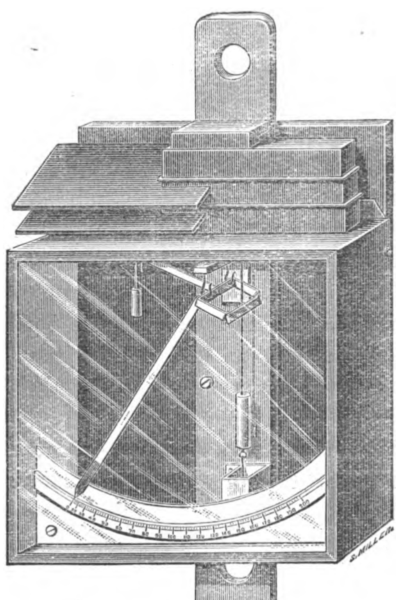

Fig. 1. AMPERE GAUGE.

for the Edison Electric Illuminating Company of New York, and which is, without doubt, the largest voltmeter in the world. I will describe it later on.

I now wish to describe another chain of instruments which are intended to record the amount of electrical energy consumed in a power or light installation. The instrument consists of an electrically-driven clock, and of an electric indicator which shows the strength of the current passing at any particular moment. This instrument is shown in Fig. 2, and details are given in Figs. 4, 5, and 6.

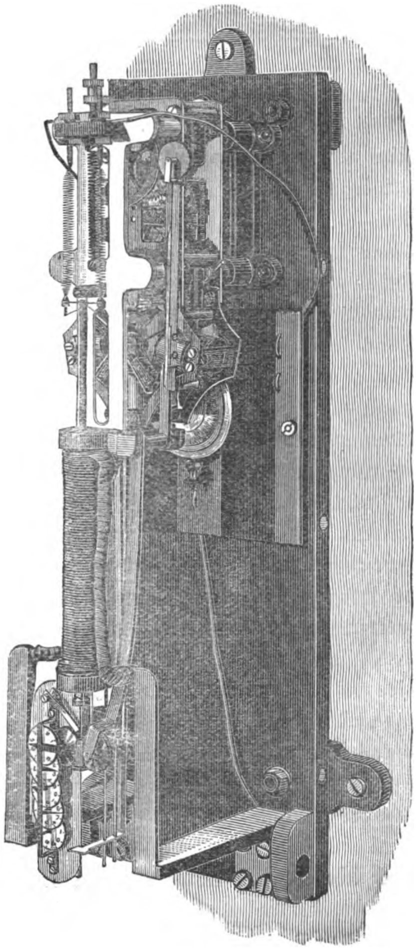

Fig. 2. Electricity Supply Meter.

Before entering into these details of this instrument as a recording meter, I shall first describe the electrical indicator, and afterwards give a description of the indicator and clock, as forming a recording electricity meter.

The electric portion of the meter consists of two parts—

1. A main coil, D (Figs. 5 and 6), which carries all the current supplying the lamps.

2. A movable electromagnet suspended upon two spiral springs (Figs. 4 and 5).

The main coil has a number of turns of copper rod wound as shown in Figs. 5 and 6. The number of turns and thickness of the rod vary according to the current range of the meter; thus, a meter

for 25 amperes has about 75 turns in its fixed coil, while a meter for 250 amperes has only eight or nine turns of heavier conductor. In the earlier forms of the meter the coils were made of a stranded conductor formed of a number of silk-covered wires, but the present form of coil has many advantages. It has its surface open to the air, and so quickly radiates off the heat generated by the passage of the current. It has also the advantage of giving a more intense field for a given cross section of conductor, because the whole conductor lies nearer the axis of the solenoid than it does in the stranded coils, the latter losing in concentration by the thickness of insulation on its different wires.

The electro-magnet consists of a soft iron bar, on which are rolled a great number of turns of very fine insulated copper wire. Soft iron is used in order to obtain sufficient force to overcome all frictional errors. The same phenomena could be obtained by the action of the main solenoid upon another solenoid of fine wire, but the force would be very feeble; this would also be the case if a permanent steel magnet were used. By the use of soft iron the force is increased more than 2,000 times over what it would be if a fine wire solenoid only were used. There is nothing new, of course, in the use of soft iron and a solenoid in electrical instruments. Many instruments have been made depending upon this principle, but most of them have not been very successful, because of errors due to residual magnetism in the soft iron. These errors are due to the fact that, if we magnetise a piece of soft iron and remove the source of magnetism, the iron will retain some of the imposed magnetism until it receives some shock or jar, when it returns at once to its original state. That is only the case with a piece of good soft iron; a piece of iron which is not thoroughly annealed will retain its magnetism in spite of a shock, and the amount of the residual magnetism is a very varying quantity, so that no good result can be obtained from it. This trouble in measuring instruments can be got over well enough for practical purposes by choosing the iron of suitable dimensions and using a very intense magnetising field. Lord Kelvin has done this in his engine-room ampere gauge (Fig. 1), in which he uses a solenoid of special construction, which gives a very intense field, and a soft iron plunger, which has a ratio of diameter to length of about 1 to 200. A bar of these dimensions is very easily saturated, so that it is found possible, with this instrument, to get a useful range free from residual

errors of about 1 to 10. That means that an instrument suited to read to 100 amperes could not be used below 10 amperes, because it would show considerable uncertainty, and would not be sensitive. In this meter it is absolutely necessary that the scale throughout should be uniform—that is to say, that the electromagnet should be pulled down a distance exactly proportional to the strength of current. It is found impossible to use the fine wire solenoid alone, because there is too little force to overcome the friction of the plunger on the side of the coil, and too delicate springs would require to be used. It is found impossible to use soft iron alone, because it does not give a uniform scale, and would be subject to the errors just mentioned. What is done, then, is to use a bar of soft iron, which is kept saturated by the current through the fine wire coil wound upon it. The current through this coil is about $\frac{1}{40}$th of an ampere, and this is about 25 per cent. more than is sufficient to keep the iron fully saturated, and makes it for the purpose virtually a permanent magnet. This is, I think, quite a new departure in measuring instruments, and allows much greater masses of iron to be used with good results, and also enables a large range to be had from one instrument.

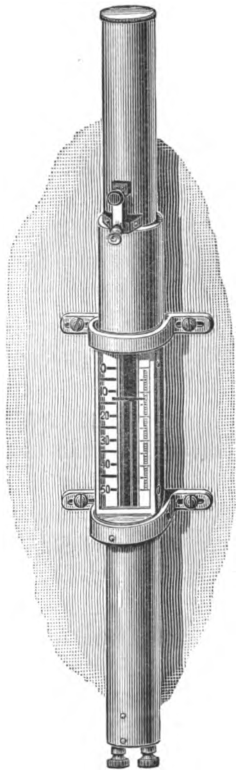

FIG. 3. TUBULAR AMPERE GAUGE.

In an instrument called the Tubular Ampere Gauge, made as now described (Fig. 3), a scale of equal divisions is procured from 0 to 50 amperes, or from 0 to 100 amperes, as will be seen. An instrument of this kind is very useful in a dwelling-house, or other installation, where it is desirable to know if all the lamps have been put out, or what number of lamps are in action.

Having now described the principle of the electrical indicator, I will speak of the details of the combination which forms the meter. The details are shown in Figs. 4, 5,

and 6. The suspended electro-magnet is shown separately in Fig. 4.

At the bottom end of the electro-magnet, A, is attached a guiding tube, I, and a loose bar, J, hangs on a projecting ring in

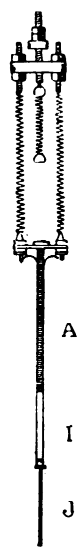

FIG. 4.

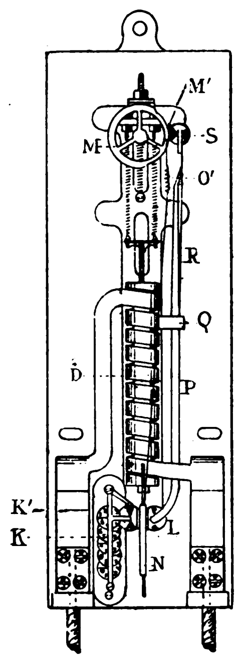

FIG. 5.

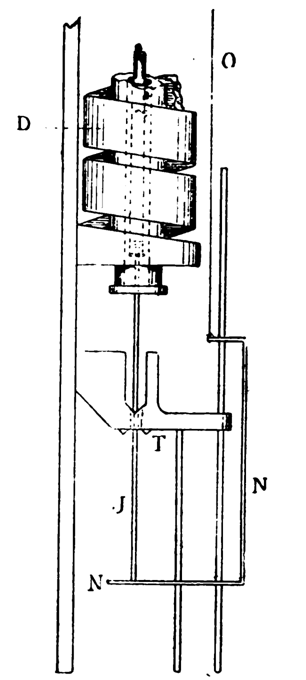

FIG. 6.

the bottom of the guiding tube. This loose bar hangs between two rollers, K′ and L (Fig. 5), which have broad, flat rims. The range of the electro-magnet, A, is fixed by stops, and the end of the bar, J, is so guided that it cannot be thrown out from between the rollers, K′ and L. At periodic intervals of time, the roller, L, is by a revolving cam, M, caused to press the bar, J, against the roller, K′, and at the same time, and actuated by the same cam wheel, M, a platform, N, is lifted till it touches the lower surface of the cheeks, T (Fig. 6), and lifts up the bar, J, and causes the roller, K′, of the counter to turn through a space proportional to the amount of current passing through the fixed coil, D.

The zero position of the electro-magnet, A, is adjusted so that the extreme end of the bar, J, just touches the platform, N, when

the latter is drawn up against the lower surface of the guiding cheek, T. The cam wheel, M, is kept revolving uniformly by clockwork, and has attached to it a stud which carries the platform, N, by a connecting wire, O, having a small spiral spring, O′. As the cam wheel revolves, the platform, N, is lifted till it presses against the lower surface of the guiding cheeks, T, and lowered till it is below the lowest possible position of the rod, J, by the rising and falling of the stud, M′. The roller, L, is pivoted to a rod, P, attached to a crosspiece, Q, which is pivoted to the framework of the instrument. Also attached to the crosspiece there is another spring rod, R, which carries a roller, S, which is kept in contact with the cam wheel. While the portion of the cam wheel, which is of larger radius, is passing the roller, S, the roller, L, is pressed forward, and the loose piece, J, is nipped between the rollers, L and K′. At this time the platform, N, is at the bottom of its range.

If a current is passing through the fixed coil, D, the electromagnet, A, and consequently the bar, J, are pulled down by a corresponding amount, and the platform, N, in its upward motion carries the bar, J, back to its zero position, at the same time turning the rolling wheel, K′. When the platform, N, first touches the lower surface of the guiding cheeks, T, the stud on the cam wheel is not quite at its highest position, and while it rises to it the spring, O′, is elongated. When the stud begins to fall the spring contracts, and at the same time the bar, J, is unclamped from between the rollers, K′ and L, so that by the time the platform, N, begins to fall, the bar, J, is hanging quite free. When no current is passing, the bar is clamped at its zero position, and the platform, N, on being lifted, touches the end of the bar and the lower surface of the guiding cheeks at the same time, and no record is made on the roller, K.

Description of Large Dial Voltmeter for the Edison Electric Illuminating Company, of New York.

This instrument depends for its action upon the pull of a solenoid, C, on a suspended electro-magnet, P. Fig. 7 gives an external view, and Fig. 8 shows the internal arrangements of the parts. P is a plunger of soft iron about 60 cm. long, and about 1 cm. in diameter, which has a coil of about 30,000 turns of fine wire wound on it. The current is conducted into and out of this

circuit by means of two spiral springs, SS, which also serve to support the weight of the electro-magnet. The resistance of this

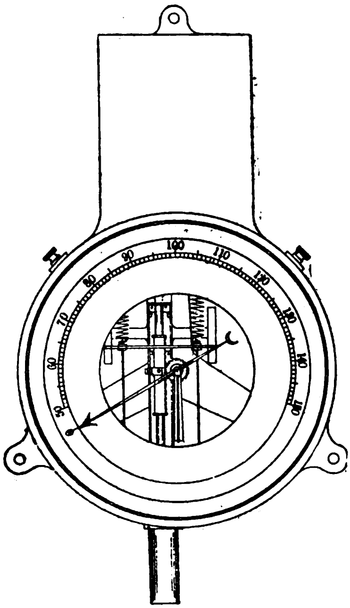

Fig. 7.

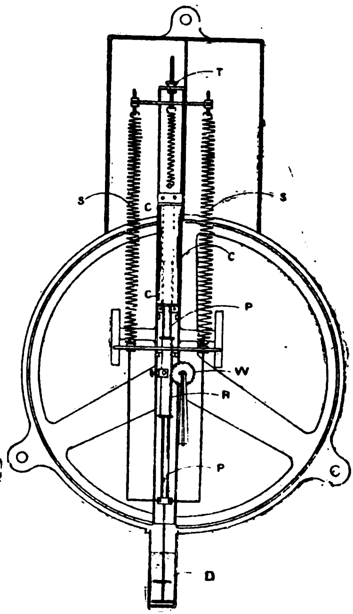

Fig. 8.

circuit is about 1,500 ohms, and it is found that a current of $\frac{1}{25}$th ampere is sufficient to saturate the iron, so that from 60 volts upwards a scale is obtained free from "residual" errors. The electro-magnet is suspended, with its upper pole entered about three diameters inside the main solenoid, C, at zero position. T is a screw for adjusting the zero of the electro-magnet. Attached to the electro-magnet is a rack, R, which is geared into a pinion wheel, W, on a shaft carrying the pointer. When a current is passed round the solenoid, C, the electro-magnet is pulled up, and so turns round the pinion wheel and hand. The scale, after the plunger is saturated from 60 volts upwards, consists of equal divisions. A rod, carrying two discs, is screwed into the lower end of the electro-magnet, and the discs, working in thick oil in a dashpot, D, serve to damp vibrations due to sudden changes of E.M.F.

XII.—*The Light Sense in relation to Navigation.* By Freeland Fergus, M.D., Surgeon to the Glasgow Eye Infirmary.

[Read before the Society, 22nd March, 1893.]

The proposition which I wish to establish to-night is, that although the testing of the colour sense is a matter of great importance for safety in navigation, yet the examination of the light sense is at least of as great, if not even of greater, importance. To make our meaning perfectly obvious, it may be well to give some indication as to what is meant by the light sense. The information gained by the brain from the act of vision is not simple but complex. It includes knowledge of the form, of the colour, and, within certain limits, of the position and relative distance of objects in space. Thus we judge one object to be nearer than another because a greater nerve effort is required to focus one object on the retina than another. Moreover, a greater amount of convergence is required for a near object than for one more remote. These, certainly, are two factors which help us to what may be called the unconscious estimation of distance. Nor do the factors already mentioned involve all the functions of vision. Physiologists describe another set of sensations which are included under the heading of the light sense. By that is meant, in its broadest acceptation, the power of distinguishing light without reference to the colour, or size, or form of the object from which the light comes. Thus, on closing the eyes tightly, and on facing a source of light, such as a gas flame, or facing a window, if the hand is passed rapidly in front of the eyes, the person is at once aware of the fact that the hand is passed, and can indicate, without the least difficulty, the precise moment at which it passes. On this function depends the power of distinguishing shadows, of telling when one black is more intense than another, and, if the expression is allowable, of seeing objects in the dark.

The following incidents may help to explain the object of these few remarks. Some two years ago, I happened to be on the

esplanade at Oban, on a dark night, along with a friend, whose vision, as far as regards the length of sight and acuteness, was quite as good as my own. The night was dark, yet one of us could quite well see the loom of an island a little way down Kerarra Sound, and the other could not. This I believe to have been due to a difference in the light sense. Take, again, the following:—In coming in from the western ocean on a somewhat thick evening, four persons were busily engaged in trying to pick up the land; two of them saw it, but the other two did not, although all four held certificates from the Board of Trade, and had presumably passed the required examination as regards eyesight. That is a difference which we are probably entitled to refer to some variation in the light sense of the observers. Take yet another example:—Imagine a low-lying island. Some persons can see such an object at night against a black cloud more easily than others. Our proposition is that, at any rate for inland navigation and for pilotage, it is quite as important to test the power of distinguishing shadows as it is to test the power of distinguishing colours.

I have no wish to under-estimate the importance of testing the colour sense, but, with all due deference to the excellent work of many who have laboured in this department, it would seem that the colour-blind danger has been somewhat exaggerated. As a plain matter of fact, no distinct case is on record of a ship being lost because those in charge were colour-blind. In that admirable report lately published by the Royal Society's Committee on Colour-Blindness, in what may be termed its mercantile relations, no case of such a casualty is mentioned, with the doubtful exception of H.M.S. *Iron Duke*. Further, it is admitted on all hands that a person, though colour-blind, may be able to distinguish between a starboard and port light. I say that no accident at sea, so far as is known, has ever been absolutely traced to colour-blindness. Many who are apt to take an extreme view of the danger assert that there is a high probability of some of the casualties that have not been traced to their origin being due to colour defect. But surely we can only argue of the unknown from known data, and, till more direct evidence is forthcoming, no strong generalisation can be made.

As already stated, some persons who are colour-blind are able to distinguish a green from a red light. This is a well-recognised fact, and hence special precautions have to be taken in testing for

colour-blindness. With careless testing, a man may answer the colours well enough. He does so because, from experience, he has learned to associate a particular luminosity with the name of a colour. Moreover, most colour-blind subjects have a large number of their sensations quite normal.

I do not intend to discuss colour-blindness to-night. Suffice it to say that, although in view of an extremely careful paper by Professor Rutherford, of Edinburgh, at the last meeting of the British Association, we can scarcely accept the Young-Helmholtz theory; yet, as a matter of fact, most colour-blind persons have in the spectrum a neutral line, corresponding to white. From this it follows that if the starboard and port lights are made of coloured glass, taken at a considerable distance from the average neutral line, then most colour-blind people can distinguish the one from the other. While, therefore, we would undoubtedly prefer to be at sea with officers and look-out men with perfect colour sense, yet we cannot help thinking that the actual danger from this defect has been somewhat exaggerated.

The exhaustive report of the Royal Society's Committee on Colour Vision deals to some extent with the form sense, but does not mention in the least the light sense, and, believing that it is of the first importance for home-trade navigation, I have ventured to bring the subject before this Society.

Different persons differ from each other in their power of seeing in subdued light, and that apart altogether from any error of refraction or accommodation. There are differences in this respect which we may count within normal limits, and defective sight in this direction is often brought on by disease. A person so affected may have perfect form sense in a good strong light—that is to say, he may in a bright light be able to read the smallest test letters at the standard distance, but utterly fail to do so in a bad light. As a matter of fact, shipmasters often complain that individual members of their crews have not very good sight at night: that is a common experience.

Physiologists, moreover, have pointed out two phases of this light sense. (1) Let us begin with an eye looking into absolute darkness, say, into a black box perfectly light-tight (see diagram, page 180). Let the eye be placed at the eye-piece A, and let there be some test objects, such as a few squares of white paper, at the other end. If now a standard candle be placed at B, and light therefrom gradually admitted into the box by the gentle opening

of a rectangular diaphragm, there comes a time at which the eye first distinguishes the light reflected by the white paper. The size of the opening is then a measure of the least amount of light which will give rise to a luminous sensation. On examining a number of persons, it is found that the size of the opening requires to be larger for some persons than for others, and, therefore, it follows that the minimum amount of light which will give rise to a luminous sensation differs in individual cases. The arrangement just described is what is known as the retinal photometer of Foerster. This is an observation of considerable importance to the physiologist, but it is not of such importance, from our point of view, as the other aspect of the light sense.*

(2) There is considerable variation in the power of distinguishing between the addition or subtraction of light. Let us

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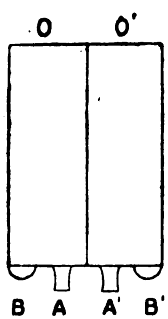
* In the annexed diagram there is represented, in longitudinal section, a double photometric box of Foerster, an instrument which I have adapted for the purposes of an ordinary photometer, in order to get an electric light of a known strength. The parts lettered A and B are sufficiently explained in the text; it may not, however, be out of place to say a few words as to its general application. The test objects which are most suited for photometric work are lines of small print, and precisely similar sets are placed at O and O′. Each compartment of the box is perfectly light-tight, and quite independent of the other. The observer's eye is placed at A, and light is admitted from a standard candle at B by the gradual opening of a rectangular diaphragm. At the opening of the diaphragm there is placed a piece of slightly opaque glass.



As soon as the eye at A can read the letters at the other end of the box, the observer stops opening the diaphragm, and notes on a scale the size of the aperture. He then opens a perfectly similar diaphragm before the electric lamp at B′ to exactly the same amount, and places the same eye that he used in the previous experiment at A′. By means of a rheostat, the light of the lamp is gradually increased till the eye is just able to read the words at O′. The candle and the lamp must then have precisely the same power of illumination so far as the light and form senses are concerned.

By such an arrangement the physiologist can always make sure that he is using the same strength of light for perimetric work. The electric light renders the use of the perimeter in a dark room possible, and hence the disturbing element of daylight and of reflected daylight is done away with. Further, by making the end of the box movable, on the same principle as the camera, the box may be used for general photometric measurements.

suppose that, with a Clerk Maxwell's rotating disc, we mix white and black so as to produce a grey, we can alter at pleasure the relative amounts of white and black, and thereby produce greys of different luminosities. Suppose the experiment starts with exactly one-half of the disc covered with black and the other with white, and if, after a time, the least change is made, so that there is a little more black than white, say, 182° of black and 178° of white, then some eyes can quite easily tell the difference, although others can not. Sometimes as great a difference as eight degrees, or even more, has to be made before some eyes perceive the difference in the grey.

For sake of greater ease in manipulation, we have arranged a box with three such discs, each being driven at such a speed as to cause absolute blending of the white and black so as to produce grey. The centre one is always run exactly half and half—half white to half black. One of the others has a little more white than black, and the other a little more black than white.

When the discs are allowed to rotate, if the alterations are exceedingly small, the white being very nearly equal to the black in the outside discs, many eyes even in a strong light do not discern any difference in the three. As a rule, however, it is found that the average eye in very good light can tell a difference, on comparing a disc in which the black and white are in equal proportions with one in which the sector of white is about two degrees greater than that of black, or *vice versa.* Some eyes, however, do not recognise any change unless the one sector exceeds the other by as much as eight degrees, or even more. In such cases the eyes have often perfect form sense, as is shown by the fact that they are able to distinguish all the test letters at the standard distances—at least in a good light, but will not do so in a bad one. Now, what I hold is this—that persons who have this defect are quite unsuited to have charge of a vessel, at least and in so far as they may be required to keep a look-out. A person so affected must have the greatest difficulty in distinguishing between one dark object and another. Officers in the home-trade navigation have been heard to say that one of their greatest difficulties at night, in narrow waters, is to distinguish where the land ends and the water begins. Similar to this is the difficulty of picking up at night an object, such as a beacon, or other mark, against a dark sky. To a person gifted with good light sense, observations of this kind are

always difficult; to a person affected with a deficient light sense, they must be quite impossible.

As regards the practical testing of this function of vision, a few words are not uncalled for. The exact testing even of the colour sense is a matter of very considerable difficulty in certain cases. The Committee of the Royal Society have agreed to recommend Holmgren's wools, and in this they have probably made the very best selection. Short of the spectroscope itself, there is no method of testing so good. It is to be hoped that before long the Board of Trade will instruct the marine examiners to use only Holmgren's test, for the present tests are not fair either to the public or to the candidate. A man who is not colour-blind may, by the present method of testing, be rejected; and, again, we conceive it possible for a man who is colour-blind sometimes to pass the required tests. This latter possibility, however, is not so likely to happen as the former.

For the testing of the light sense, some system of rotating discs is probably the best. The one generally used by physiologists and by medical practitioners is the rotating disc of Masson. It consists of a white card with a few black spots on it. On rapid rotation, the effect produced is of a series of grey rings differing in darkness, and the person undergoing examination is simply asked to count them. A person with defective light sense fails to do so accurately. Possibly it would be better, and would test more perfectly the condition we wish to investigate, if the disc were made entirely of black, with a few white spots on it.

Bjerrum's types are also extremely useful. These types are arranged on precisely the same lines as the types of Snellen, only, instead of black letters on a white ground, they consist of grey letters on a white ground. Such types are, I believe, the best as yet made for testing the light sense; and as they also are available for testing the form sense, it is much to be desired that the Board of Trade would universally adopt them for testing all sailors.

It seems probable that even a better arrangement would be to have a perfectly black background with letters composed of a less saturated black—that is to say, very dark-grey letters. Such would seem more to fulfil the conditions of the case.

Another instrument sometimes used is Chibret's. That is one which is of some service to an unskilled examiner, but one which seems to lead to many serious errors.

It is much to be desired that we had some methods of practically testing the strength of daylight, or, at any rate, of comparing the luminosity of light on any day with a given standard. Although much of practical value has already been done in testing the light sense, yet it is to be feared that no absolute standards of the light sense can be obtained till we are able to express daylight in actual figures.

XIII.—*On Special Applications of the Telephone.* By WILLIAM AITKEN, Assoc.Inst. E.E., Engineer to the National Telephone Company.

[Read before the Society, 19th April, 1893.]

THE telephone, in its short career of something like fourteen years, has so thoroughly established itself as an aid to business that in many ways it is looked on as being indispensable. Not only, however, does it enable business to be more quickly transacted—saving time, and, therefore, making money for the happy renter,—but in nearly every department of municipal and social life it plays an important part, and it is to this side of the subject that I wish to draw your attention to-night.

Already we have our police offices all over the country and all local ones in communication; and in central positions, in districts where it is not desirable to have offices, ornamental iron boxes have been erected and all joined to the central office by telephone, so that intelligence can be sent from point to point.

Our fire brigade now carries the telephone with it as an indispensable piece of apparatus. When the scene of the fire is reached, it is immediately connected with the nearest fire alarm, which has a similar instrument connected with it at the central fire station, and communication is thereby kept up. Further supplies can be obtained promptly, and the firemaster and other officers advised of any other fire that may occur.

The ambulance waggon can be called out from any subscriber's office, and thereby many an unfortunate being has been saved an hour or two's agony. Our infirmaries, hospitals, asylums, and numerous charitable institutions have this convenience, and find it of very great assistance in carrying on their good work.

It is only within the last few years that the telephone has been taken up to any extent in our homes, and even yet the instrument is often relegated to some odd corner or dark closet. Here, however, it proves "a friend indeed," by bringing the housewife

into touch with all the tradesmen in the neighbourhood, the police, fire station, and—greatest blessing of all—into communication with the doctor, and with the office of the breadwinner of the family. If the latter should fall sick, the telephone is brought out of its obscurity and set by the bedside. No need now for him to worry that the business will not be prospering in his absence. He can ring up in the morning to learn what letters there are, and dictate his replies. If an important client calls, he can have a consultation by telephone. His mind is easy, and recovery is all the quicker in consequence.

All the principal doctors now have the telephone, and can be got hold of by night and by day. You can even have your consultation by telephone: you tell your symptoms to the doctor, and he can judge whether it will be necessary to get up out of his comfortable bed into which he has just turned after a hard day's work, or whether you can wait till morning. Some have two switches, one in the consulting room, into which the instrument is plugged during the day, and one in the bedroom, to which the instrument is removed at night.

These switches should be in every private house, and are becoming more and more common as the telephone becomes popular. You can have the instrument in a closet for the servants answering, but for special purposes, such as a chat with some friend, or when listening to church service or theatre performances, it should be transferred to one of the public rooms of the house.

The transmitting of the church service and theatre performances has never got much beyond the experimental stage. There is as yet no very great demand for these, and the opposition of the church has prevented any decided advance in that direction.

Some little time ago we made an attempt to get two churches of each denomination joined up in Glasgow, but we met with so much opposition, and got credited with so many bad motives, that we gave up the attempt. Whether the fear is that the churches would lose in the way of collection if the people were allowed to listen in their own homes, or whether it is that the attendance would go down, I am not quite sure. If the former, they might do as, I am told, is done at Christ Church, Birmingham. There, after the usual offertory is announced, one of the churchwardens, who has a telephone in his pew, intimates to the listeners at a distance that "those who have had the privilege of listening by telephone might kindly forward their contributions by post," and

I am informed that larger amounts are got in this way than would have been contributed had the listeners been present.

As regards emptying the churches, Bellamy, in that interesting book of his, "Looking Backwards, or Life in the Year 2,000," makes the ministers preach in special acoustically-prepared chambers, from which radiate wires to the listeners' houses.

We have only the Rev. David Watson's (Woodside Parish) Church connected in Glasgow; and two churches in Greenock—one a Wesleyan, and the other a Congregational one—make up the total number connected in all South Scotland.

As regards the theatres, we have them connected simply as a novelty, and there is no regular service for the public getting connection. Should the demand increase, however, it will be necessary to make arrangements with the theatre proprietors, and make a small charge to the subscribers.

It is not possible to give the best possible results to private houses, inasmuch as to attain that it is necessary to have two separate circuits with special apparatus in each; but what can be given is fairly good, music—both vocal and instrumental—coming through rich and clear.

Bellamy, in the book before referred to, tells us that in the year 2,000 the dwelling-houses will have a specially-fitted room for hearing the church and theatre in. All that will be necessary to get connection will be simply to turn one or two screws; when the room will become flooded with the melody. In the bedrooms will be a somewhat similar arrangement, but with receiver to be put to the ear, so that any other occupant of the room need not be disturbed, it being within the power of the listener to regulate its loudness. After being soothed to sleep by the soft strains, he can be wakened by more stirring music in the morning at any hour to which he may previously have set a clockwork arrangement.

All this can approximately be accomplished in the year 1893. As demonstrated to you here to-night, we can sit and listen to the theatre performance, even though we might be a hundred or two hundred miles away. (Fig. 1.) We have, however, usually still to ask you to hold the receiver to the ear, as all instruments for commercial use are preferred to be silent to all persons but the one directly listening. Instruments of the other form will, I have no doubt, become more common when the people demand them; in fact, there are one or two now made, one of which, by the kind-

ness of Mr. Ward, of the General Electric Company, I am able to show to-night. The other day music was transmitted over a line 1,000 miles long, between New York and Chicago, and heard over the room.

DIAGRAM OF THEATRE CONNECTIONS.

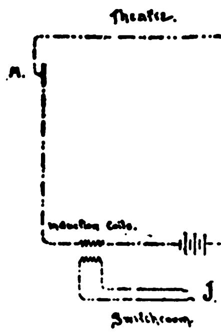


Fig. 1.

Another point to which we have not yet attained is that of simplicity of connection. We still require to ask the switch-room operator to connect us, and it is a little difficult to see how turning a screw or two can connect with one of a dozen or more different places, so that it looks as if it would be necessary to lead a dozen or two wires into each house.

A few months ago, we connected two telephone receivers to the bedside of a person who was ill for a considerable period, and the patient, along with the nurse, was able to pass a few hours each evening listening to the operas and pantomimes, and on Sundays listening to the church service, and this about ten miles away from Glasgow. We can only get this pleasure for a few hours out of the twenty-four, but Bellamy tells us that, in the reorganised world, 110 years after this, they will have music all day long. Performances will follow each other, so that the music will never cease. The music will be grave and gay, secular and sacred, in different halls, so that the would-be listener can select that which best suits his mood.

Even before this is extended to our homes, I think it might be extended to those places where persons have to reside who are shut out from many of the pleasures of life—those living in the homes for incurables, fever hospitals, infirmaries, &c., where, I am certain, it would come as a great treat, and help to pass cheerfully many a

weary hour. This could quite easily be accomplished, as most of the places mentioned have already the connection to the Telephone Exchange, and the wire is lying very nearly idle in the evening and on the Sunday. A simple switch arrangement would be placed beside the ordinary instrument, with a wire running from one side of it to the receivers in the ward or convalescent room, and all that would be necessary to get connection would be to ring up the Exchange in the ordinary way, and then turn the switch on to the receivers.

Another way in which the telephone can facilitate work and relieve the worker in large establishments is that the telephone should take the place of all bells, be they mechanical or electrical. What unnecessary labour is incurred in getting what you require? You are, say, in the top flat and want hot water. You ring the bell; the servant climbs the stair, and hears your request, "Bring me hot water, please." She returns to the place from whence she came, and gets what you wanted, and then returns, having twice ascended and descended the stair, when one trip might have done if you had had the telephone.

Formerly it meant that you must have a switch-board, and some one to attend to it, so as to put you in connection with whatever part of the house you wished to speak to. Now, however, by a multiple system of wiring, you can talk from one room to any other room in a comparatively large establishment without any assistance. One wire is run for each instrument to all the different rooms. If there are to be ten instruments, then ten wires leave a switch at No. 1 instrument to go to a similar switch at No. 2, and so on to every room to be connected. Preferably these wires should be made up in cable form, for the sake of compactness and allowing neater work to be done. Each switch has as many contact points as there are rooms, and by putting a plug into a socket, or turning a pointer to a certain number, you get connection with the room wanted.

The trouble with most of these is that any prying person can listen by putting the instrument in any other room also in connection. This is rather objectionable, and there are one or two arrangements for overcoming it, but they are rather complicated. I have designed one (Fig. 2) for a new installation which the National Telephone Company are about to erect in a city merchant's office, which, I think, will do its work very well. It will be impossible to overhear with this; and while the different rooms are fitted

up as a single-wire system with one wire for each instrument, yet when talking the two wires of the two instruments in use will be used as outgoing and return, forming a complete metallic path.

INTERNAL TELEPHONIC INSTALLATION.

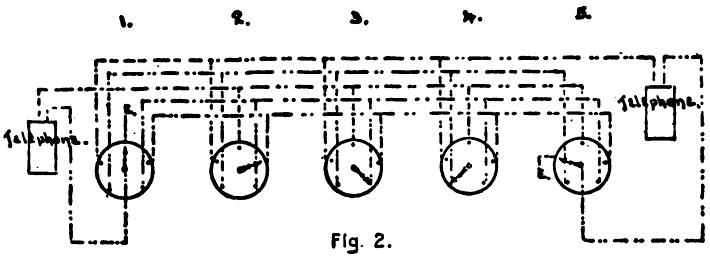


Fig. 2.

In conclusion, allow me to say that I believe that in the near future the telephone in the private house will be considered as much a necessity as the gas and water, and that no house will be reckoned complete without it. It may not be necessary for each tenant in a block to have one, but there will be one common to a number, so that it will be within the reach of all.

Description of Figures illustrating Mr. Aitken's Paper.

Fig. 1.

This shows the method of joining up the theatre to the telephone switch-rooms in Glasgow. The microphones (MM) only are in the theatre, two in each circuit, one being attached to each side of the proscenium. The induction coils and battery are in the switch-room, so that all operating is done there. A connection is led to the ordinary spring-jack, J, for subscribers getting connected at.

Fig. 2.

Here is represented an installation of five stations, say, in a warehouse or large factory. If No. 1 wishes to talk to No. 5, he turns his switch-pointer to "5," and rings through earth. No. 5 replies, and, if it is desired that the conversation be private, he turns his pointer to "1," when the circuit is completely metallic.

XIV.—*Notes of a Mining Engineer's Visit to South Africa.* By ALEXANDER GEORGE MOORE, M.A., B.Sc., C.E., and M.E

[Read before the Society, 19th April, 1893.]

PLATE VI.

AT the request of your Secretary, I have to offer a few remarks on mining development of South Africa which came under my notice during a late professional visit.

I arrived at Durban, in Natal, on 4th January last, and, after spending a fortnight in the colony, proceeded to Johannesburg, the seat of the Transvaal gold industry, in the neighbourhood of which I spent three weeks. I returned to Natal, and went by sea to East London, from which I made a short visit to Kimberley Diamond Mines, leaving South Africa on the 1st of March. (See Plate VI., Fig. 1.)

Durban is the seaport of the colony. It is a town of considerable size, with good streets and buildings, and a population composed of whites, blacks, and Indians. There is a good harbour, which takes in ships of 19 feet draught. Unfortunately there is difficulty with the sandbar at the mouth of the harbour, and, although very extensive works have been carried out, it is still a matter of difficulty to keep an open channel.

The business part of town is about a mile and a-half from the harbour, on the shallow water of the bay. Behind the town is the Berea—a wooded eminence,—where there are numerous villas, the residences of the wealthier townspeople. There is a fair water supply, but no drainage. There is no gas supply in the town, and electric light is only in operation at the town buildings.

Tramways run from the harbour, or Point, where a number of stores are situated, to the town and the Berea.

The country commences to rise right up from the sea, reaching a height of 2,200 feet at 'Maritzburg. Along the coast the climate is tropical, and sugar, bananas, pine apples, coffee, tea, &c., are grown. Even as far as 'Maritzburg fruits grow well.

Beyond 'Maritzburg the ascent still continues, and at Dundee, the centre of the Natal coalfield, the altitude is 4,100 feet above the sea. At this height the country is purely pastoral, being divided into large farms, principally owned by the Dutch. The climate is excellent.

Very little was done towards developing the mineral resources of the colony till, in 1880, the Natal Government appointed Mr. F. North to report on the coal-bearing districts of the colony. The government railway, of 3 feet 6 inch gauge, had then only been constructed from Durban to 'Maritzburg—the capital of the colony—a distance of 70 miles, and Mr. North reported that very large areas of coal of good quality and thickness existed in the Klip River District, over 200 miles from Durban, and only wanted railway communication to utilise it for the benefit of the colony. The railway was then extended through the coalfields, and collieries were opened out.

The geological position of the coal-bearing rocks is supposed to be in the triassic formation. The low rocks have not been definitely correlated, but the general succession in descending order is as under:—(1) Basaltic trap rocks; (2) triassic horizontal coal measures; (3) 'Maritzburg shales; (4) conglomerate or boulder clay, which is a characteristic and persistent formation; (5) sandstones, probably of silurian age; (6) primary rocks. These measures lie very flat, and the outline of the country going north from Durban ascends pretty much with the geological succession.

Although the area of workable coal extends only 50 miles along the line of the railway, the coal measures form a large area in the colony. The measures are all very flat, and the coal is readily accessible at the outcrops in the valleys. Even in this area it is questionable if the coal exists with great uniformity, as numerous provings put down by the Government or by private individuals have shown that in many places the coal strata are disturbed sometimes by erosion, and sometimes by the overflow of trap.

This coalfield may be divided into four sections, going north:—(1) Sunday River District; (2) Dundee District; (3) Ingagane Valley; (4) Newcastle District.

Sunday River District extends about 20 miles, from Elands Laagte to Uithoeck, about 3,600 feet above the sea level, and 200 miles from Durban. The seams are thin. Generally two

seams are found, separated from each other by about 3 fathoms of strata. I visited the Wallsend Colliery, where a 21-inch seam is worked by longwall, 50 men being employed. The output was about 30 tons of screened coal per day.

The Dundee District is 240 miles from Durban, and 4,100 feet above sea level. There is only one seam found here, which is split up by partings, so that only a working of 4 feet is left. I visited the Dundee Colliery, where this seam is worked in an extensive manner. It is connected to the main line at Glencoe Station by a branch line, 7 miles long, which was constructed by the Colliery Company at a cost of £47,000, and is also the passenger line to the small town of Dundee and Coalfields. It is in the direct route to Zululand and the Vreiheid District of the Transvaal. There are two pits, 75 feet deep, 300 yards apart. The manager and other officials are nearly all Scotchmen, and all the arrangements above and below ground are after the style of a Scotch colliery. The working is by stoop-and-room. The manual work is performed by Kaffirs and coolies, under the supervision of Europeans. There are 27 Europeans, 420 Kaffirs, and 90 coolies employed. The Kaffirs are principally Zulus—strong, well-made fellows, with no education, and not speaking English. They soon learn to use mining tools, especially to strike with the hammer. They have no great skill as picksmen, although they work hard. As you enter a gallery you often hear them singing, in their deep voices, to the accompaniment of the strokes of the pick. When at work they are quite naked. Their engagement is by the month, and the employer provides them with huts and food. They are mostly young fellows, and in most cases come of their own accord seeking work; but there are persons who make a business of procuring them for the companies. Few of them stay long at work in the mines; they go back to their kraals, but sometimes return. The huts are made of corrugated iron, without floors and windows. A number of men occupy each hut; they have no beds or bedding, and lie huddled together on the floor in their rugs and blankets. They come generally in parties, and all the members of a party are very particular about getting into the same hut. The only food they get is "mealies," or Indian corn meal, which their employer supplies from the colliery store, and they cook for themselves. I believe they get meat once a week. They have no women with them. They get a ticket for each day's work, including Sunday,

on which day, however, they do not work; and they get their wages at the end of the month. I understand that the raw Kaffir has no count of time by days or years. My information is that, so long as he is unconverted, he is a fine animal, honest and dependable, but requires to be firmly dealt with. The coolies are native Indians sent by the Government, with free passages, and are indentured for five years, at 10s. a month, rising a shilling a month each year. Their food is rice, which their employer provides. After they have completed the indenture they may seek employment on their own terms, or return home at the expense of the Indian Government. Physically, they are inferior to the Kaffirs, but of a higher type of intelligence, and became blacksmiths, enginemen, and carpenters. They are never put to supervise natives. They live by themselves, apart from the Kaffirs. There are only coolies employed in the mines in the colony, and I believe they are not a success.

For mining, Kaffir labour is not cheap; even if constant work is obtained. A Kaffir, in Natal, costs 2s. per day, and he does not do half the work of a Scotch miner. The cost of working coal here is nearly twice as high as it would be in Scotland.

The coal in the Ingagane Valley has not as yet been opened up since the extension of the railway. The valley is 260 miles from Durban, and 4,000 feet above sea level. It contains a 10-feet seam, with about 8 feet of workable coal, having a sandstone roof. Considerable provings have been made in this district, and there is a large area of coal, lying flat and from 5 to 50 fathoms from the surface, close to the railway. Preparations are now going on for opening up this valuable field.

Newcastle District is about 7 miles further on. It is about 270 miles from Durban, and 4,000 feet above sea level. I visited the Newcastle Colliery, which is about 5 miles from Newcastle, a small and prettily-situated town with about 1,000 inhabitants. It was for two years the terminus of the railway, but the extension of the line to Charlestown has now shorn it of its prestige as a terminal station. The colliery has been promoted by a number of the inhabitants of the town, and the workings are on the town lands. The seam has been opened up by an adit mine. It is worked on the stoop-and-room system, and is 5 feet thick, with a parting of 14 inches of shale about 15 inches from the bottom. The coal is of a highly bituminous character, resembling our Scotch house coal. About 98 Kaffirs, 28 coolies, and 8

Europeans are employed. The output is about 50 tons per day.

Generally the coal of Natal may be said to be of very good quality, and better than any other coal I saw in South Africa. It varies in quality, in different districts, from anthracitic to bituminous, but coal suitable for steam, smithy, or household purposes may be obtained. From trials made, it gives only 15 per cent. less heating power than Welsh steam coal. The present output of the colony is about 140,000 tons per annum. Part of this is used for Government railway and other works, part for ships' bunkers, and the remainder, about 30,000 tons, is used in the colony. In the last three years the output has increased from 35,000 to 140,000 tons, and no doubt the proposed extension of the Government line through the Transvaal, and the general expansion of trade that will result from this, will increase the demand for coal.

The Natal Government is fully alive to the importance of developing the mining resources of the country. There is a Commissioner of Mines at 'Maritzburg who publishes statistics of the progress of the mining industry, containing particulars of the number of men employed, and the outputs at each colliery, and also any records of mining discoveries. He also takes charge of the leasing of the Government mineral lands, and has diamond boring drills exploring the country. The drills are in charge of competent workmen, and any prospector can hire them at moderate rates. Railway rates are only ½d. a ton per mile, including the use of waggons, and the price of coal at Durban Harbour is 20s. per ton.

Outside of coal, mining in Natal cannot be said to have made much progress. I am told that gold has been found at Umsinto, Umsingo, and Umvoti, and that considerable prospecting has been done, but no practical success has been attained. Provings have been made in Vreiheid District, which is a little corner of the Transvaal bordering on Natal and Zululand, and a company has been formed to treat the ore by a new process. Large deposits of magnetic iron ore are said to exist at Prestwick, near Dundee.

The working of coal has contributed very materially to the prosperity of the colony. Independently of the impetus given to trade, it has saved the colony the purchase of 90,000 tons of coal per annum, or £180,000, and brought in an outside trade of

£50,000,—and this is to a country where the total exports of colonial produce in 1891 were only £970,000.

After leaving Newcastle, the railway ascends the Drakensburg Range, 1,300 feet, to Charlestown, a scattered village 300 miles from Durban, and 5,300 feet above sea level. It is situated on the Transvaal border, at the foot of Majubah Hill, of inglorious memory. From here the journey to Johannesburg—a distance of 135 miles—is by coach, over a comparatively flat table land, which forms the watershed of the country. The only river of any size is the Vaal, which is crossed by an iron girder bridge at Standerton, a town of some size, where one puts up for the night. The country passed through is pastoral. The next town reached is Heidelberg, a Dutch town, 40 miles from Johannesburg. The country in this neighbourhood is very pleasant—trees, fruit, and flowers growing well. At one of the changing stations there was quite a pretty orchard, with a garden having roses in full bloom. The country approaching Johannesburg is bare plain or veldt, with no cultivation. Under ordinary circumstances, such as I met with on my return, the coach journey is a very pleasant one.

The coaches are made in the style of a waggonette, with light iron frame roof and waterproof flaps, which can be fastened down at the sides and doors in wet or dusty weather. They hold about a dozen people. The luggage is rested on two shelves on each side, and roped to the coach. A team consists of five pairs of horses or mules. The two wheelers are harnessed to the pole, and the rest of the team by traces to a light chain attached to the pole. The harness is light, and is changed very quickly by the stable boys at each stage. These coaches run from 8 to 9 miles an hour, and change teams at least every 10 miles. The conductor, or driver, sits in front. He has a "boy" alongside, who holds the reins while he handles the whip, unless in going over some difficult piece of ground, when he takes the reins himself. There is practically no road, only a track over the veldt, which is altered as it gets cut up. During my up journey there were heavy rains, and several of the brooks had become rivers, which necessitated, among other discomforts, passengers getting out of one coach to be ferried over to another. Our time got all wrong, and instead of having no night travelling, as advertised, our second day's stage was from 5 in the morning till 4.30 next morning, when we reached Johannesburg, ten hours behind time. The time occupied in the journey from Durban to Johannesburg is 18 hours by rail and 30 by coach.

The town of Johannesburg to-day contains about 50,000 inhabitants; seven years ago its site was an uncultivated plain. Then the Transvaal Government "proclaimed" nine farms for gold-mining, and by January, 1890—two and a-half years,—there were 450 companies in operation, with a capital of £11,000,000. The town was planted down on the outcrop of the gold rocks—canvas being replaced by corrugated iron, and this, in its turn, by bricks or stone, until the town reached its present proportions. In the centre of the town there is a large open square, forming the market-place. On the west side of the square are the Government offices, and all round are substantial buildings. The chief thoroughfare, Commissioner Street, is one block to the north of the square, and runs east and west, being lined on each side with substantial buildings of brick and stone, in which are the stores, shops, and offices, banks, and mining exchange. To the north and east and west, you get into the suburbs. The streets are lighted by gas, and the market-square, hotels, and theatres, by electricity. Locomotion is not difficult; a tramway runs through the town to the suburbs on each side, and any number of Cape carts can be hired. A local railway, a concession to the Netherlands Company, runs 20 miles west to Krugersdorp, and 30 miles east to Springs. It was only at the end of last year that the town obtained railway connection with the Cape railways, and with Pretoria, the capital of the Transvaal. There is now direct railway communication with Capetown, Port Elizabeth, and East London—the shortest distance being 800 miles, to Port Elizabeth. The town has a water supply, which I believe is very inadequate at times; but there is no system of drainage. The streets are badly kept, having no formation. In dry weather there is a depth of several inches of dust, and in winter, when the drought is continuous, I believe the high winds raise clouds of dust which are seen miles off, rising to a great height. The streets are a striking contrast to those of Durban in this respect, which are macadamised and regularly watered in dry weather. During the summer months, from January to March, is the wet season, and it *does* rain sometimes. One sees the main street like a small river at twelve o'clock, and at five there is just a suspicion of dust beginning to show itself.

The gold does not exist in veins, but in stratified beds (locally called "reefs") like coal-seams. The rock bearing the gold is called "banket" or "almond rock," and is a conglomerate of fine quartz pebbles in a matrix of iron pyrites. The precious metal

seems to adhere to the outside of the pebbles, but is not visible to the naked eye, unless in a very rich specimen. The rocks accompanying the reefs are quartzites. There are several recognised reefs of banket, but they vary considerably at different points; and, indeed, there is doubt as to the identity along the line of outcrop. The names of the principal reefs opened out are, in descending order:—South reef, 6 inches to 3 feet; middle reef, 6 inches to 2 feet; main reef leader, 6 inches to 2 feet; main reef proper; north reef. The workings are principally in the main reef leader, south reef, and middle reef. Several reefs to the south have been opened out—including the black reef, which has been profitably worked,—but have not been worked to a large extent. A reef called the Duprees reef, about a mile and a-half to the north of the line of main reef, is worked at the new Rietfontein Mine, which is giving very good results, but has not yet been proved of good quality outside of their property.

Exploration of the reefs has been made along the outcrop for a distance of about 15 miles to the east of the town, and 35 miles to the west. About 12 miles on each side of the town, between Durban Roodeport and Witwatersrandt, the beds are in their best condition, and the most successful results have been obtained. At this point the strata dip south, at an angle of from 30 to 60 degrees. The general idea of the formation is that it is a basin, the beds flattening as the depth increases until they rise to the opposite edge. The western edge of the basin has been established. At the Nigel Mines, 35 miles south-east of the town, the dip of the reef is to the north-west. Right to the south of the town, however, no trace of a northern dip has yet been discovered, so that the area of the formation is still an open question.

The general mode of mining is to drive down mines in the reef from the surface, and sink shafts to catch it at some distance back from the outcrop—a method of working somewhat similar to our longwall working in steep seams, the whole of the reef being carried forward in a face between the levels, which require to be kept well in advance, so as to develop new ground. This is a heavy item in the expenditure of the mine. At the outcrop, and for about 50 to 100 feet from the ground, the banket is weathered, the pyrites being oxidised. It is here soft and easily mined. As the mines get deeper the rock becomes harder, and unaltered pyrites is present in the banket. None of the shafts is of any great depth yet; the deepest I was down, the "Robinson," being

about 100 yards. A dip mine was about 200 feet further down. The pumps at this mine were the largest in the district. There was a 10-inch ram, with 4-feet stroke, but this did not go constantly, unless in wet weather.

Dynamite is used for blasting the rock, the holes being drilled by Kaffirs. In free-working rock, two Kaffirs put in four holes in a shift. When the rock gets too hard, compressed-air percussion drills are used, which give very satisfactory results. One man puts in five holes three feet deep in a shift. The use of compressed drills adds to the cost of working, but gives greater speed. The levels in hard rock cost as much as £20 per fathom. Candles are used for lighting, and are quite an expensive item. Our Scotch lamps do not seem to be popular in South Africa. The ventilation of the mines is not specially good. As yet there are no ventilating fans on the Randt.

Considering that they had all to be conveyed on bullock waggons a distance of 150 miles, the mine machinery and erections are very good. The boilers are mostly of the locomotive type, but return tubular and Babcock & Wilcox boilers are being introduced. I believe there are only two Lancashire boilers in use, but now that the railway is into the town probably more will be used. The water is injurious to the tubes. Generally speaking, the arrangement of boilers and steam pipes in the mines that I saw seemed to be the least satisfactory part of the plant.

There is no great quantity of water as yet in any of the mines. Most of the pumping machinery is rather poor. The general type is the Cornish pump with tee bobs and wooden rods driven from a geared wheel. There is a great weakness for small steam pumps, which are very unsatisfactory, and not economical.

The mines that I visited were the best in the district, but the general impression one formed was that, so far as the engineering part of the work went, they were in capable hands, and the incompetent management of which so much was formerly heard had now mostly disappeared. It seems to me, however, to be a mistake not to open up the reef by dip mines from the surface, as in our shale workings in Scotland, where the inclination of the seam is very similar. Johannesburg mining men might learn a good deal from them, both in the manner of extending the mines, and in raising the minerals and water.

The following is a brief description of the treatment of the ore after it comes from the mine. It is brought up in side-tipping

tubs, drawn off the cage, and tipped into a breaker. In the newer fittings, before passing into the breaker, the ore is tipped on to a floor, wetted, and selected by hand. The crushed ore is then conveyed in tubs to the mill, where it is passed through the stamps. Most of the gold is caught in the amalgamating plates in the mortar box, and the crushed sand, containing gold in suspension, is flushed through a sieve with 800 to 1,200 meshes to the square inch, whence it runs on to amalgamating plates set in front of the stamps, where more gold is caught. It is then concentrated by passing over rough-flannel cloth (blanketing), or by mechanical concentrators, which catch the heavier particles of sand and gold, the tailings running to settling ponds. The amalgamating plates are cleaned at intervals, and the gold separated from the mercury by retorting.

This completed the treatment, so long as free-milling ore was worked, and most of the gold was obtained. When pyritous ore began to be worked, it was found that about 40 per cent. of the gold was going off in the tailings, and it was found necessary to recover this. The two methods adopted for this purpose on the Randt are the chlorination process and the cyanide process. The former is only suitable for concentrates. At the chlorination works of the Robinson Mine, the process is as follows:—The tailings, after passing over the amalgamating plates, are concentrated on Frue vanners, and are then taken to the chlorination works and allowed to dry. They are then passed through roasting furnaces at a temperature gradually increasing to a bright red heat, being kept stirred during the process. This drives off the sulphur. The material is then put into vats, and chlorine gas passed through it. It is afterwards lixiviated, and a solution of gold chloride is run off into vats, and the gold thrown down by sulphate of iron as a black precipitate.

The cyanide, or MacArthur-Forrest process, is as follows:—The tailings are collected and tipped into large tanks and lixiviated with weak solutions of cyanide of potassium, which dissolve the free gold. The solution containing the gold is then pumped into a tank, where it passes through zinc shavings, which deposit the gold as a black sediment. This process is economical and is giving good results. An objection to this process is the presence of zinc and lead as impurities in the gold obtained. I understand that several processes for separating the gold from cyanide solution by electrolytic action have been tried, but none is in practical

operation. The special success of the cyanide process is said to be due to the flaky nature of the gold, which renders it difficult to concentrate. Possibly by greater care in concentration, results by chlorination might be obtained which would render the cyanide process unnecessary.

All manual labour is performed by Kaffirs under European supervision, the general conditions of employment being the same as in Natal. Labour is scarce, and a Kaffir costs about three shillings a day. The Kaffirs are rather a mixed lot here, and inferior to those in Natal.

The Randt is strong in statistics, not collected, however, by the Government, but by an elected body called the Chamber of Mines, which is an institution whose function is to look after the mining interests of the country, and especially to take a protective interest in the Government legislation so far as it affects mining. A monthly return is published, giving the number of tons of ore crushed and the yield of gold obtained at each mine. The annual report contains a *précis* of the year's transactions of the Chamber, and returns of labour, consumption of stores, dividend list, and working returns of each mine. In addition to this, the companies publish in the newspapers annual, and in some cases monthly, statements of the most complete description, giving quantities, cost of production, and financial statements. The following figures, taken from the published report of the Robinson Gold Mining Company, show the cost of working for six months ending 3rd December, 1892 :—

Tons hauled and crushed, - - -	50,461		
	£	*s.*	*d.*
Mining and mine maintenance, - -	0	13	9·37
Milling and mill maintenance, - -	0	4	0·01
Development, redemption, and general maintenance, - - - - - -	0	8	5·51
General charges, - - - - - -	0	2	4·23
Total cost per ton, - - - -	1	8	7·12

MacArthur-Forrest Process.

Tailings treated, - - - - - -	40,050 tons.
Gold extracted, - - - - - -	7,887 ozs.
Actual gold recovered, - - - -	62 per cent.
Cost of treatment (including royalty), -	8s. 8·7d. p. ton.

The following figures, taken from the Chamber of Mines Report, giving the Witwatersrandt gold production for year ending December, 1892, are interesting:—

Tons (of 2,000 lbs.) milled, - - -	1,979,354 tons.
Yield of gold, - - - - - -	973,291 ozs.
Do. per ton milled, - - -	9·77 dwts.
Value of gold, - - - - - -	£3,506,787.
Do. per ton milled, - - -	£1 15s. 3d.

The total gold obtained, including concentrates and tailings, was 1,210,868 ounces, worth £4,297,610, being an increase of 480,000 ounces over last year.

Only 26 out of 74 mining companies on the list paid dividends, which amounted to £795,000, about 7 per cent. of the capital of the 74 mines, or 16 per cent. on their own capital. One mine—the Robinson—paid about 24 per cent. of the whole dividend, giving only 7 per cent. on its own capital. The highest rate of dividend was that of the Fereira, which was 125 per cent. on a capital of £56,000. The number of men employed, including those at collieries and prospecting work, was estimated at 2,791 whites and 25,858 natives. The stores used by 36 companies amounted to £1,750,000.

It is fortunate for Johannesburg that it is situated alongside of a coalfield. The quantity of coal used at the mines is over 200,000 tons per annum, and the total quantity used in the district must be nearly 300,000 tons. Coal is delivered to the mines at an average cost of 23s. per ton. All the collieries are within twenty-five miles of the town. The nearest is at Boksburg, fifteen miles away, where the coal seam is now supposed actually to lie unconformably on the gold-bearing strata. This is only a small basin, and there are about half-a-dozen small collieries working in it. The coal is about 80 feet from the surface; it varies greatly in thickness, and is as thick as 24 feet; it is of poor quality, and ribbed with coaly slate.

Five miles further to the east is Brakpan, the principal colliery in the district, which has an output of 184,000 tons per annum of screened coal and nuts. The seam is similar in character to that of Boksburg, but of better quality, and the basin is of larger area. Improved screening and picking machinery has been put up here. I descended into the workings. There are two pits, about 70 feet deep to the coal, which is from 6 to 20 feet thick, and lies flat.

It is worked on the stoop-and-room system, the pillars being left 50 yards square, and worked off by driving places through them, leaving small pillars, 8 feet square, to support the roof. There must be a large amount of coal lost. Dynamite is used in working. It is a dirty coal, containing 18 per cent. of ash. The dross is unsaleable, and is deposited in heaps on the surface, which ignite spontaneously, and burn away.

Five miles still further east are Springs and Castle Collieries, the former having elaborate surface arrangements which have been put up at great cost.

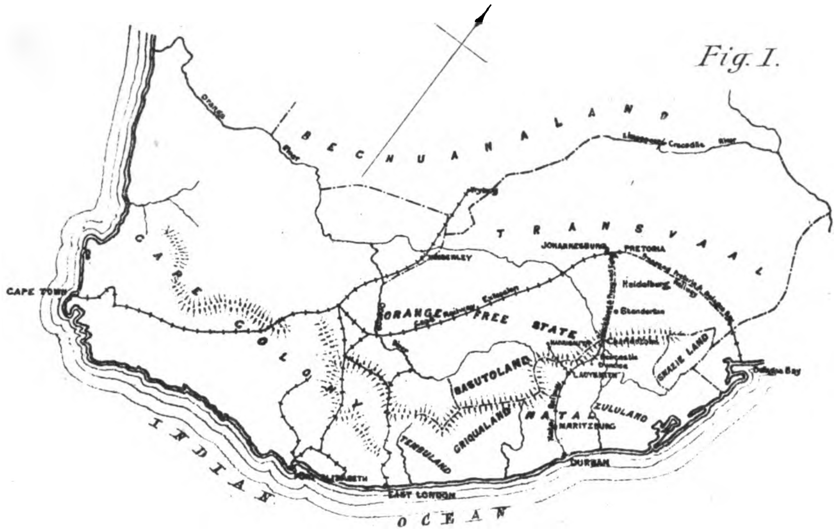
The coal industry is much hampered by the insufficient arrangements on the railway; there are few sidings, and the coal requires to be put in bags, and carted from the stations to the mines in bullock waggons.

About thirty miles further east, at the Vilgoa River, the edge of a large tract of coal-bearing strata is reached. I saw some outcrops here, and found the coal much superior to that nearer Johannesburg. The policy of the Transvaal Government in granting a concession to the Netherlands Company has put a premium on railway transport, which would stand in the way of this coal being introduced. Their rate is 3d. per ton per mile, and 4s. for each waggon; this is a striking contrast to the Natal Railway rate of ½d. a ton per mile, which is cheaper than our Scotch rates.

I have devoted a considerable amount of space to Johannesburg mines, but really they are in a sense South Africa, and on their development depends, in a great measure, the success of the other colonies. Should the anticipation be realised that the beds flatten to the centre of the basin, and only dip steeply at the edge, as is the case in all mineral basins, Johannesburg may have an area of 1,000 square miles of gold-bearing strata, and be the largest gold-producing district that the world has ever seen.

I shall close my remarks with a short description of a visit to the Kimberley diamond mines. Kimberley, as you all know, is the centre of the diamond-producing district. The town is situated in the midst of a barren country, which, but for the existence of the diamonds, would probably be uninhabitated. The mines are now practically in the hands of the De Beers Consolidated Company, which in 1887 bought up the claims of the numerous companies engaged in diamond working. This amalgamation, which was carried through by the Hon. Cecil Rhodes, had become

Fig. I.



MAP OF SOUTH AFRICA.

SCALE

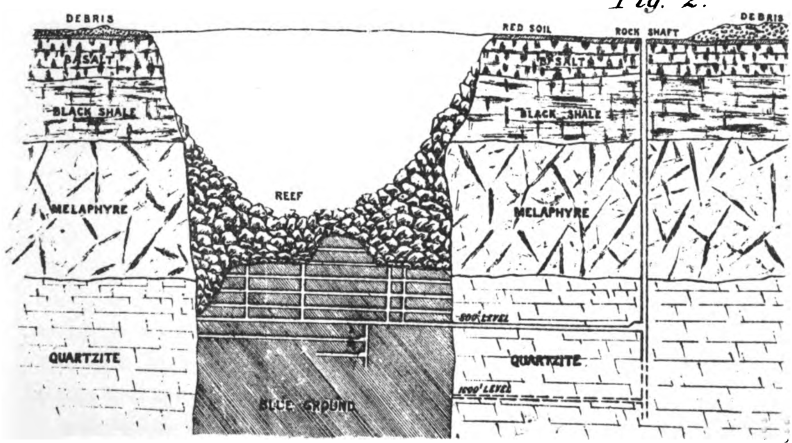
Miles 100 50 0 100 200 300 Miles.

DE BEERS MINE

Vertical Section of strata illustrating the method of working the Diamond bearing rock.

Scale 600 Feet to one inch.

Fig. 2.



a necessity to the economical working of the diamond rock. The diamond-bearing rock is found in large pipes or funnels, more or less oval in shape, 10 to 30 acres in area, and of unknown depth. They are supposed to be the craters of extinct volcanoes which have been filled up with volcanic mud. The rock is of a tough, soapy texture, and contains a number of minerals, among which are olivine, magnetite, and garnets. At the surface the rock was of yellow colour, but below a depth of 50 feet it got to be of a blue colour and much harder. Originally the rock was quarried, and this style of work was carried on to a depth of 400 feet, by a very large number of operators, the material being raised to the surface by aërial rope tramways. I visited one open-cast mine at Bultfontein, and saw this system in operation. It worked in a very satisfactory manner.

The present system of mining, which is illustrated on the accompanying sketch (Plate VI., Fig. 2), is to sink shafts through the barren rocks outside of the reef, and drive level mines into the diamond-bearing rock or "blue." The company have two fittings in operation, one at De Beers Pan, and the other at Kimberley. They are about half-a-mile from each other. In the De Beers Mine, which I descended, the diamond-bearing rock is at present 625 feet from the surface of the pan. There is a thickness of about 100 feet of rubbish on the top of it. The rock is worked off in layers 30 feet thick; the levels and opening-out places are driven in six feet high to the boundary, and have a roof of 25 feet; and the whole layer is then "back-stooped" towards the shaft—the rubbish on the top following down the excavation. Each layer is like a separate seam, and a number are worked at one time. In this way the danger from side falls, which occur in open working, is avoided. "Stooping" was going on from the 625-feet level to the 800-feet, where the material was all hoisted to the surface. The levels down to 1,000 feet were opened out, and made ready for stooping to be commenced; and the shafts have reached a depth of 1,200 feet. At the bottom of the shaft the rock is tipped from the tubs into a large skip, holding six tubs, which empties itself at the top. There are two of these skips running, and the operation is so quickly performed that by the time that the skip at the top empties itself, the signal is given to hoist away from the bottom.

All the surface machinery and fittings are of the most perfect description, and designed to give economy in steam, as coal is very

expensive. Cyphergat colonial coal is at present being used. It is very inferior. Formerly Welsh coal, costing over £8 a ton, was employed. The pumping engine at Kimberley Mine is of the triple-expansion type.

The process of obtaining the diamonds from the rock is very elaborate. The rock from the blue ground is conveyed to the floors, which are large areas of waste ground, and is spread out in layers about 15 inches thick. It is there left for several months, and is disintegrated by the action of the atmosphere. It is then taken to the washery, where it is screened, the small pieces passing into the washer, and the larger pieces being returned to the floors. In the washer, which is a pan filled with water, and having revolving stirrers, the heavy deposit containing the diamonds is separated from the lighter, which flows off. The diamond deposit is then taken to the pulsator, in which it is separated into four sizes by a revolving screen. The largest size passes over; the others pass into jigs, or bash washers, and the heavy deposit containing the diamonds is drawn off through a pipe. These deposits are then taken to tables and picked by hand. The picking is gone over twice by white men, and then, when dry, by native convicts. Out of 7,200 loads washed (of 16 cwts. each), 72 loads are sent to the pulsator. Of these, six pass over the screens, and 24 pass through the jigs, making 30 loads taken to the assorting tables, and in these 30 carats of diamonds or 95 grains weight are obtained. The natives are all kept in compounds here, which they are not allowed to leave unless at the end of their month's engagement, when they are subjected to a close examination.

The De Beers Company publish most elaborate statistics and financial statements. They have a capital of £3,950,000 and £4,000,000 of debentures. Last year the profit and loss account showed a credit balance of £1,190,000. Over 2,000,000 tons of blue ground were raised, the cost of working being about 10s. per ton, and the price realised about 27s.

This great company is now practically a kingdom in itself. All the officials employed by the company live in a village apart from the town, in the company's property, and the natives are kept in compounds. The effect of this is rather an interesting study in social and political economy. While the output and value of diamonds have not decreased, and the profit obtained is much greater, the town of Kimberley is in a languishing condition,

because all those who were interested in the working of the small mines have quitted the town for new ground, and left the townspeople without trade.

I may say, in conclusion, that my visit to South Africa was a most pleasant experience. The sea journey is made with as much comfort as on any other line of first-class steamships, and the land journey is as comfortable as any railway journey in this country. The climate is delightful, and medical men say very suitable for invalids. To any one who has the time to make the journey, I would say he should not hesitate to do so, for I feel certain he would enjoy it.

OTHER MEMOIRS OF DECEASED MEMBERS OF THE SOCIETY.

XV.—Obituary of W. R. W. Smith.

By J. B. Russell, M.D., LL.D., Past President of the Society.

William Rae Wilson Smith was born 9th November, 1817, at "Bellegrove," the new-fangled name given to that part of the old "Witch Loan" between Duke Street and the Gallowgate when it was laid off as a villa suburb. It survives in the plebeian guise of Bellgrove Street. His father, Alexander Smith, had been Deputy-Governor of Sierra Leone. His mother was a daughter of John Phillips of Stobcross. Another daughter married William Rae, who afterwards assumed the name of Wilson, on succeeding to the property of an uncle. Young Smith was named after this uncle of his. The complexity of the name was more remarkable in those days than it would be now. A still-surviving school-fellow writes—"He was a bright, kind-hearted fellow, fond of his fun, and who did not mind being made fun of, for which his preposterously long name very often gave occasion." We know that, to his latest day, he was familiarly spoken of as "Alphabet Smith." But there is more in the name than matter for a joke. It is a picturesque mnemonic of Glasgow notabilia, and contains the evidence of its bearer's descent from the "blue blood" of Glasgow. William Rae Wilson, after inheriting his uncle's fortune and estates, had the misfortune to lose his wife, and sought for solace in travel. He published several works, but his "Travels in Egypt and the Holy Land" (1823) made the most mark, brought him the distinction of LL.D. from the University, and is specially mentioned on the remarkable tomb erected over his grave in the Necropolis. His memory is kept green by the "Rae Wilson Gold Medal," which he founded, and which is annually bestowed in the University, in the Faculty of Divinity, for the best essay on a Messianic subject. The uncle whose name Dr. Wilson assumed was John Wilson, one of the town-clerks of Glasgow. Part of his inheritance was Kelvinbank, where he resided. The land now forms part of the West-End Park, but the natural features of the site of the mansion-house were wholly destroyed in the preparations for the late Exhibition.

Smith was educated at the Grammar School, where he was a prize-taker. One of his school-fellows was the late Dr. R. Angus Smith, F.R.S., with whom he maintained a life-long acquaintance. Another was John A. Russell, Q.C., whose recollections of the school-boy have already been quoted. They did not meet again for full fifty years; but we have his testimony that in all the most marked characteristics of his boyhood he was unchanged, which all who knew Mr. Smith can readily believe, for no better conception of the man could be expressed than Mr. Russell's description of the boy—"a bright, kind-hearted fellow; fond of his fun, and who did not mind being made fun of." From school Smith went straight to business, after a short probation starting as a yarn merchant and agent, which he continued to be until his retirement in 1888. In the course of his business he travelled frequently in all the chief European countries. It need scarcely be said that he was a thorough Free Trader. He was one of the local committee which brought Cobden and Bright to Glasgow. He was an advanced Liberal, working for the Reform Bill and every subsequent measure in the constitutional evolution of his country; but when Gladstonianism came to be the measure of men's fitness to be recognised as a Liberal, he could not accept the terms, though if ever man was by mental constitution and natural temperament a Radical, he was.

Throughout his life Mr. Smith took an active interest in local affairs. He was not one of those who thought that the whole duty of citizenship consisted in prosecuting his business in his warehouse and on 'Change, withdrawing every night to dine and pass a quiet evening at home in the suburbs. Whether in the city or the suburb, or in the country parish where he spent the summer, wherever he was a ratepayer, and had therefore a voice and interest in local government, there he raised his voice and used his influence, and always with a special regard to the improvement of the physical conditions of health. He was mainly instrumental in obtaining a water-supply for Sandbank. In Hillhead he was a constant advocate of annexation to Glasgow, as in the councils of his own city he promoted the same policy with regard to all the burghs which grew up on her borders. His antagonism to the administrative isolation of those suburban districts arose from his sympathy with the corporate life of the community to which they essentially belonged. He had seen them grow up around the one hearth, and knew that they were

still fed from the one table. The indecency, not to speak of the injustice, of their affectation of independence, and the repudiation by them of their duties towards their poor relations, rankled in his soul. It was a great joy to him in the adversities of his declining years that he lived to see the passing of the City of Glasgow Act in 1891, which once more united the majority of those erring children under the old roof-tree.

Mr. Smith entered the Town Council as one of the representatives of the 7th Ward in 1874, and continued to represent it until 1888, when misfortune overtook him in business, and he tendered his resignation, which was accepted with heartfelt expressions of sympathy and regret, and ample recognition of his long and able services. During those fourteen years Mr. Smith identified himself especially with the work of the Committee on Health—first as Convener of the Sub-Committee on Cleansing, and then, on the elevation of the Chairman, Mr. John Ure, to the Lord Provostship in 1880, as the successor of that gentleman. In these capacities Mr. Smith was ceaseless in that which was to him, in the fullest sense, a labour of love—the building up of that system of cleansing and general sanitary administration which has made Glasgow a model among cities. The utilisation of the rubbish and the disposal of the sewage of the city were problems which fascinated Mr. Smith's mind, and with which his name was thoroughly identified by the public. He was an active member of the deputations sent out by Glasgow, in 1877 and 1880, with a roving commission extending to the Continent, to collect information as to systems of sewage disposal. Their reports were drafted by Dr. Wallace and Mr. Smith, and have taken their place in sewage literature, and in the very limited part of it which is practical, trustworthy, and sensible. After the Health Committee, the business of the Committee on Libraries most attracted his interest. He vigorously advocated the adoption of the Free Libraries Act. In short, everything that tended to promote the material comfort, the mental and moral improvement of the masses, and their enjoyment of life, found in him an untiring advocate. Though frequently urged to enter the magistracy, Mr. Smith always declined to do so. He was a day-by-day Committee man rather than a fortnightly or monthly Town Councillor. He was proud of being Chairman of the Health Committee, but he did not seem to care for titles and robes as such.

Mr. Smith was elected a member of the Philosophical Society

in 1868. He first took part in its business early in session 1868-69, by speaking in a discussion on the Sewage Question. In 1869, a Sanitary and Social Economy Section was organised under the Presidency of Mr. Charles Randolph, with Mr. Smith and Dr. Fergus as Vice-Presidents, all of whom had been active and prominent members of the Glasgow Sewage Association, whose separate existence ceased when it was notified to the members that the Philosophical Society would form a Section for the consideration of the Sewage Question and other sanitary subjects. In 1870 Mr. Smith was elected to the Council of the Society. In 1874 he was made President of the Sanitary Section. After passing the chair, he was put on the Council of the Section, and kept there until his death. Although he only read one paper before the Society (5th March, 1873, "On the Present Aspect of the Sewage Question, and what Glasgow should do in relation to it"), Mr. Smith was a most valuable member. He seldom missed a meeting, and the President could generally trust to his quick wit and readiness of speech to break the silence which so often follows the reading of a paper, and so set a discussion agoing. There is, perhaps, no single member whose name appears so often in the minutes, not merely as a speaker in debates, but in connection with much of the most important business of the Society between 1868 and 1892. We may instance the frequent discussions on the Patent Laws, and the Special Committees appointed from time to time to draw up petitions to Parliament, and watch the progress of legislation thereon; the discussions on Technical Education; the arrangements for the reception of the National Association for the Promotion of Social Science and the British Association; the Committee appointed to approach the Town Council regarding the Mitchell Bequest and the adoption of the Free Libraries Act; the Committee on Accommodation, which resulted in the erection of our present rooms; the procedure connected with the Incorporation of the Society; the efforts of the Society to promote the Amendment of the Public Health (Scotland) Act, and of the Burials Act; the Executive Committee of the Society's "Exhibition of Apparatus for the Utilisation of Gas, Electricity, &c." His name appears for the last time in the minute of meeting, 3rd February, 1892, among the speakers in the discussion of a paper on "Fogs."

After his business reverses in 1888, Mr. Smith spent much of his time in retirement at Rosmor, his quaint and pretty little place

on the Holy Loch, among his orchids and his vines, cheered by the society of his children and grandchildren. He watched with unabated interest the doings of his old colleagues in the Town Council from the loopholes of his retreat; delighted when he could tempt any of them or their officials to spend a night with him to discuss the business of the great city in which his heart lay; and, when he failed in that, sending them letters to cheer them when the battle seemed to be going against them, or to congratulate them when success crowned their efforts. Throughout the contests which preceded the passing of the Police Amendment Act, 1890; the City of Glasgow Act, 1891; and the Building Regulations Act, 1892, he kept closely in touch with his friends in the Council, and especially with Mr. Crawford, his successor in the Chair of the Committee on Health. He was always invited to the little junketings with which municipal work is occasionally relieved and promoted. On such occasions he was the youngest of the company; still the Grammar School boy—"a bright, kind-hearted fellow; fond of his fun, and who did not mind being made fun of." In March, 1892, he suffered a slight shock, which was the beginning of the end. The writer of this notice preserves, with affectionate interest, a postal card written with unsteady pen, in which, after saying how pleased he would be to see Mr. Crawford, he proceeds—"I quite recognise the milestone I have passed, and only weary at so possibly many in this impotent state, but I must trust the Higher Will, and so be still. It may be a resting-place for me to make me more meet." He reached the end of his journey on 31st January, 1893. In 1864 he lost his wife, Annie M'Ewen, daughter of John M'Ewen, iron merchant, but he left behind an unbroken family of five sons and one daughter. Mr. Smith was all his life an Episcopalian, but in religious matters he was thoroughly unsectarian. To him all men were brothers, sons of one all-wise and loving Father. He was intolerant of ecclesiastical domination and dogmatism. Still it was obvious to those who knew him intimately that he dwelt habitually on the borders of the unseen; a devout man, who knew his Bible well; who enjoyed the wine of life, but at times would go from the feast out into the darkness and the silence.

XVI.—OBITUARY OF SIR MICHAEL CONNAL.*

As Sir Walter Scott says in his autobiography, "Every Scottish man has a pedigree." The family from which Sir Michael Connal descended was settled in Stirlingshire about the middle of the sixteenth century. The Connals were farmers in the western district of Stirlingshire till the end of the seventeenth century. Some of them were strong Covenanters, and fought along with Ure of Shirgarton at Bothwell Bridge in 1679; and a certain Donald Connal appears to have had rather an adventurous time of it. A nephew of this Donald was Patrick Connal, the great-grandfather of Sir Michael. According to the Burgh Records, he was a prominent burgess and guild brother of Stirling in 1745. He married Isobel, daughter of Michael Downie, and grand-daughter of James Christie, Provost of Stirling, and their eldest son was Michael Connal, born in 1752. Through his mother's connections he came in for a fair share of the good things of Stirling.

The Christies held good positions in the army and in law and commerce. One of them, General Gabriel Christie, was Commander of the Forces in Canada in 1798; and his brother, William Christie, was one of the burgesses who, in 1777, established the Stirling Bank. Having no family, he bequeathed his property, including his shares in the banking company, to his relative, Michael Connal, who was a merchant and banker in Stirling, and for many years Provost of the Burgh. He was a keen politician, and a man of strong character. He died in the office of Provost in 1812. His death was said to have been caused by the great excitement which he had undergone during the Parliamentary contest which took place that year, and which pressed heavily on him in consequence of having been disappointed in his object—the return of Henry Brougham (afterwards Lord Brougham) as M.P. for the District of Burghs. He married Miss Marion Glas, sister of Provost John Glas of Stirling. Their

* For most of the information contained in this Memoir the Editor is indebted to a gentleman who was intimately associated with Sir Michae Connal for many years.

eldest son was Patrick Connal, who succeeded his father as a banker in Stirling. He was the father of William Connal of Solsgirth, at one time a partner of Sir Michael's. The fourth son was William Connal, Lord Dean of Guild of Glasgow, and for many years head of the firm of William Connal & Company. The third son was Michael Connal of Parkhall, at one time in the Honourable East India Company's service, and his wife was Eliza Wright, daughter of William Wright of Broom, an old Stirlingshire family, and their elder son was Sir Michael Connal, the subject of this notice.

Sir Michael Connal was born in August, 1817, in one of the old mansions still standing in Miller Street, then belonging to his uncle, Mr. William Connal, his father being in India. Sir Michael was the first of the Connals born in Glasgow, rather an interesting fact, considering how closely he was to be connected with the city throughout his life. On his father's return from India the family went back to Parkhall, and Sir Michael used to tell many amusing stories of his boyhood at this quiet country retreat. His father, after this, lost money, and was obliged to sell his property and return to India, where he died in 1829. At this time Sir Michael was only twelve years old. His distress, especially for his mother, was very great, and this sad event seemed to arouse him into thoughtfulness all at once. He was educated at a private school, and afterwards at the University of Glasgow, where he showed considerable ability; but he did not continue long enough at college to make his mark there. His first intention was to have gone to the Scottish Bar, but his uncle having offered him an opening in his office he accepted it, and thereafter became completely identified with Glasgow.

The commercial house into which Sir Michael entered has an interesting history. It was founded in the latter half of the eighteenth century by William Cunninghame of Lainshaw, the "Great Virginian." In 1774 the designation of the firm was Cunninghame, Findlay, & Company, then large tobacco importers. In 1783 it became Robert Findlay & Company; in 1789, Findlay, Hopkirk, & Company; and about 1802, Findlay, Duff, & Company. It was into this firm that the late Mr. William Connal was admitted a partner in 1812, then one of the most extensive colonial and general mercantile establishments in Glasgow. The members of the firm at that time were Mr. Findlay of Easterhill, Mr. Buchanan of Blairvaddich, Mr. Dennistoun of Kelvingrove,

and others. Upon the dissolution of this firm in 1822, Mr. William Connal became the manager and active partner of the house of Findlay, Connal, & Company. This firm was dissolved in the crisis of 1826, when the general mercantile and colonial business was separated from the cotton branch, the former being carried on by Mr. William Connal under his own name till 1845.

This gentleman was a most enterprising merchant, and, besides managing his own business, was one of the original partners in the Cunard Company; and along with Messrs. Ross, Corbett, & Company, of Greenock, he originated a direct shipping trade with Calcutta, which is now carried on by Messrs. George Smith & Sons. In 1845 Mr. William Connal admitted his two nephews, Michael and William Connal, into partnership with him, when the name of the firm became William Connal & Company. Subsequent to the opening of the East India trade the firm became the largest tea brokers in Scotland, and, at the same time, were proprietors of the most extensive tea warehouses owned by any private firm in Europe or America. The first direct importation of an entire cargo of tea to the Clyde was consigned to Mr. William Connal. Sir Michael spent some years in London in the house of Messrs. W. J. & Henry Thompson, the great tea brokers, in order to learn that branch of the business. In addition to this, W. Connal & Company became the most extensive iron brokers in Scotland, having large iron depots in the city and neighbourhood, containing occasionally stores of this material of immense magnitude. They were also the largest importers in Scotland of mahogany and other fine woods from all the principal tropical regions.

In 1864 the firm again underwent a change, Sir Michael (then Mr. Connal) and Mr. William Wilson, who had been admitted a partner in 1862, retaining the general mercantile and colonial branch under the old name, while Mr. William Connal took over the pig-iron department. His firm has since been known as Connal & Company. For many years the principal branch of the business of William Connal & Company has been sugar. This business is principally conducted in Greenock, and entails a daily attendance at the market there. Till within the last 12 years Sir Michael went to Greenock regularly every morning to attend the Sugar Exchange. In an interesting article on the firm, which appeared in the *Glasgow Herald* of 7th August, it was stated that William Connal & Company is the only existing firm that can claim a direct descent from the old "Virginia Dons."

Although Sir Michael was in the whirl of business, he early began to interest himself in charitable and philanthropical institutions, and this went on broadening and deepening throughout his life. There is hardly a good institution in the city that he was not connected with in some way or other. In 1848 Sir Michael founded the "Spoutmouth Bible Institute," and throughout his life he took a most active interest in it. The object of this institution was the religious and intellectual improvement of young men, especially those in the east end of Glasgow. In connection with it there were a reading-room for newspapers, a library, and a savings' bank. Lectures were given on literary and scientific subjects, and on Sunday evenings there was a bible class, which for many years Sir Michael superintended himself. He did everything in his power to stir up enthusiasm in the members, accompanying them on their botanical excursions, and arranging their annual holidays for them. He often invited them to make Parkhall their headquarters, and their records tell of many happy days spent there, and in exploring the romantic places in the district. The best proof of the success of this institution is its practical results. As Dr. Marshall Lang recently said, "It would be difficult to over-estimate the benefit rendered by it in the formation of character and true knowledge." Many men now holding positions of trust and honour testify to the influence for good which it had over them.

Education early began to interest Sir Michael, and grew almost into a passion. He firmly believed in its power to elevate and refino those who came under its sway, and although he held "old tory" views on many social questions, yet he never feared that education would take the people out of their proper sphere; nay, rather, he believed that it would reconcile many to their lot by opening up a wider interest in life, making the most sordid employment more endurable. He knew that even the rudiments of education brought light and pleasure with them by giving a key to unlock the golden doors of books.

Sir Michael was elected a member of the first School Board of Glasgow in 1872, and succeeded the late Mr. Whitelaw, M.P., as Chairman in 1877. All parties testify to his wise policy, his never failing courtesy and gentleness, his patience and firmness, and his endeavour to be fair to all. He occupied this position for nine years, having been twice re-elected to the Chairmanship, and it was on his retiral in 1885 that the Queen conferred on

him the honour of knighthood in recognition of his valuable services. He had the honour of entertaining the Right Hon. A. J. Mundella, Vice-President of the Council on Education, during his visit to Glasgow in 1884.

An interesting feature of his School Board life was the speeches which he delivered at the opening of new schools. Whenever this happened, a great amount of the old history of Glasgow and its people was resuscitated. He went into the history of the district, the property on which the school was built, and the genealogy of the proprietors, making a perfect chapter of "The Antiquary" for all persons of the "Jonathan Oldbuck" temperament. A love, almost a veneration, for anything old was one of his most marked characteristics. An old family, an old house, an old name, all conjured up the past, making it live vividly before him. A few weeks before his death he collected materials which formed a most interesting paper for the opening of the Barrowfield School in Queen Mary Street. This was read for him by Mr. Kerr, and was of such interest to those who heard it that several persons expressed the wish that it might be printed. The reporters were rarely able to do Sir Michael justice, as he led them into such byways and untrodden paths that they had great difficulty in following him.

His house at Parkhall was a fitting abode for an antiquary. Built in 1745, it had an old-world look about it, with its quaint passages, thick walls, and narrow staircase. On the walls of the ante-drawing-room hung all manner of relics, such as bullets picked up on the field of Waterloo, snuff-boxes made out of old trees, pistols, and swords, and many Indian and Chinese curiosities brought home by his father. Sir Michael's father was one of the few persons that Napoleon allowed to visit him in St. Helena, and one of the most interesting of the relics was an order of Napoleon brought from St. Helena. Sir Michael repurchased Parkhall in 1858, and presented it to his mother, with the furniture and hangings just as they were when the property was sold by his father. It had been occupied in the interval by the Fletcher family, and many interesting letters in the "Autobiography of Mrs. Fletcher" are dated from Parkhall.

Our late fellow-citizen and friend was long connected with at least four scientific societies which meet under one roof. He was a member of the Philosophical Society—one of the four—from the year 1848, and the membership roll contains the names of

exceedingly few persons now living that have been longer upon it. When his signature in the list of members is critically examined it is at once seen to be very characteristic, differing but very little from the manner in which he signed his name a few days before his lamented death (6th July). While having the same general character of that of 1848, his signature seemed even to become more flowing and bolder with the lapse of time. He was elected a member of the Council of the Philosophical Society in 1879, and was one of the Vice-Presidents during the years 1880-81-82-83. He always took an active interest in the affairs of the Society, and in his intercourse with his colleagues and fellow-members he invariably showed those remarkable qualities of shrewdness, kindly interest in everybody, and humour which characterised him wherever he was. Sir Michael displayed a great amount of interest in geographical subjects. It was to him, in conjunction with Dr. Thomas Muir (late of the High School of Glasgow, and now Superintendent-General of Education in Cape Colony), and Mr. Alexander Scott, that the Geographical and Ethnographical Section of the Philosophical Society owed its origin, in 1883. He was elected one of its first Vice-Presidents, and he continued up till his death to occupy that position. He was most regular in his attendance at the meetings of the Council of this Section, and he never failed to take a deep interest in all its affairs. He was also one of the original members of the Royal Scottish Geographical Society, and was a member of Committee of its Glasgow Branch from its formation in 1885.

Sir Michael Connal was not much given to reading papers before the scientific societies of which he was a member, but he made an exception in the case of the Glasgow Archæological Society, of which he was one of the members from its foundation in the year 1856. The exception referred to was the preparation of a most interesting communication which he made to that society in 1859, on "The Hospital of St. Nicholas," an old-world subject, which was so much in accordance with the natural bent of his mind. He was also a member of the Natural History Society of Glasgow from the year 1851—almost a foundation member,—and in that capacity he came to be much associated with the late William Gourlie, who was the first President of the Society, and, like him, a most enthusiastic cultivator of botanical science. It is interesting here to note that Hugh M'Donald,

author of "Rambles Round Glasgow" and "Days at the Coast," and Michael Connal, were admitted members of the Natural History Society on the same evening. The only other scientific body which we need mention as embracing Sir Michael in its membership was the Geological Society of Glasgow. It came into existence in 1858, and he joined its ranks in 1866. His interest in its welfare and its proceedings continued for many years.

It would take up too much space to enumerate all the other institutions which Sir Michael was connected with, as a director or otherwise, at the time of his death; but one may be specially mentioned, from his long association with it. For more than forty years he took a deep interest in Stirling's Library. Sir Michael was the oldest director, having been elected to that post in 1856. He had also been vice-president since 1879. At the centenary celebration of this valuable institution in 1891, Sir Michael delivered a characteristic speech, giving an interesting sketch of its past history and those connected with it.

Whatever Sir Michael took in hand he did thoroughly, assuming responsibility in the most conscientious manner. He was most regular in his attendance at all meetings, and nothing but illness —and sometimes not even that—ever kept him away from what he considered his duty. He never was idle for one minute. His energy, when over 70 years of age, was amazing, and made many a young man stand aghast. Sir Michael was always an early riser, and even during last winter he spent an hour or two in his library before breakfast, arranging his books and papers. His power of absolute concentration of all his faculties on the subject before him was the secret of his ability to undertake so many things successfully. He seemed to be entirely oblivious of everything but what he had on hand. His recreations were of many kinds, principally in antiquarian and archæological pursuits. Many a bit of old Glasgow found a niche at Parkhall. Whenever an old building of any interest was doomed, Sir Michael was sure to get some fragment as a reminiscence. As an enthusiastic botanist, he was familiar with the names of all the wild flowers, which were his great favourites. He had a fine eye for scenery, and, when out of doors in the country, he would draw the attention of his companions to any interesting point of view. He especially knew well the whole of the western district of Stirlingshire. The names of the hills and dales were at his finger ends, and any

historical fact or tradition was always sure to come out in conversation. An old ruin, a 500-year-old tree, a point of the Campsie Hills, was sure to bring out many an interesting old tale. His love for animals was remarkable; and if any cruelty came to his knowledge there was sure to be an outburst of indignation, with an unpleasant time for the culprit.

Although he rarely seemed absent from Glasgow, he had seen a little of the Continent; and his strong imagination and retentive memory enabled him to make more of what he had seen than many who are constantly travelling about. Whenever he went to a place, there was sure to be something interesting going on in church or state. His description of a holiday spent in Paris about 1835-6 and his adventures in crossing the frontier during the war of France with the Netherlands was most interesting and amusing.

Sir Michael was a lover of books, especially of historical ones, and he had a well-stocked library. He knew his "Scott" well, and could draw many illustrations from his characters. He was very proud of having Sir Walter's signature on one of his farm leases. Always interested himself to hear what others were reading or thinking about, Sir Michael, not long ago, said to a young friend that he would study Dante if he were not so old. He was always willing to give his advice when sought for, and his ripe and varied knowledge of men and life made him a most valued counsellor. His stern rectitude and singleness of purpose made him to be trusted by all who came in contact with him. He was a man of strong and peculiar temper, which came out especially when any question of principle was involved. His own enormous energy and strength of constitution as a younger man perhaps made him impatient of the weaknesses of others, but his sympathy broadened and his whole tone mellowed as years passed over him. He had a very quick sense of the ludicrous and a genuine delight in humour, and his own stories and reminiscences were always racily told. He kept a journal for over fifty years, in which must be many interesting records of Glasgow, past and present. Sir Michael was very reticent about politics, but the bent of his mind was Conservative. At the Disruption he joined the Free Church, and was long an elder in St. James' Church; but he had no sympathy with those who wished to disestablish the National Church. One of the last things into which he threw himself most

thoroughly was the collecting of relics for the Jubilee Memorial Exhibition of the Free Church.

Sir Michael was a Justice of the Peace for the counties of Stirling and Lanark. He took a warm interest in everything connected with the former county, and also with the town of Stirling. It is to him that Stirling is indebted for the publication of its Burgh Records. He had been a member of the Glasgow Stirlingshire and Sons of the Rock Society since 1834, and was one of the most regular attendants at its annual social and business meetings. His uncle, Mr. William Connal, was one of the seven young men who in 1809 founded this society.

As a host Sir Michael was highly entertaining, and was characterised by his old-fashioned courtesy and kindness. He married in 1864 Helen Catherine, daughter of Mr. William Leckie Ewing of Arngomery, which property he acquired some years ago. The only child of this union died in infancy. Sir Michael was prejudiced in favour of old Scottish customs and manners, and with him has gone a great store of interesting tradition. He will long be remembered in Glasgow as an excellent representative of a type—a link between the past and present—which, we regret to say, is rapidly passing away from us.

XVII.—*The late Professor James Thomson, LL.D., D.Sc., C.E., F.R.S.* By J. T. Bottomley, M.A., D.Sc., F.R.S.

James Thomson, lately Professor of Civil Engineering and Mechanics in the University of Glasgow, was born in Belfast on the 16th of February, 1822.

His father, Dr. James Thomson, was a remarkable man. A few words here respecting his life and character will not be uninteresting or out of place, because, beyond all question, his two distinguished sons, James and William (Lord Kelvin) inherited from their father education, cultivation, and a lofty conception of life and duty, which have proved as conspicuous before all men as their unusual talents.

James Thomson, the father, was born in the North of Ireland, where the family, originally Scotch, had lived for several generations on their own small farm of Ballinahinch. With a natural craving for knowledge, and struck with a desire to understand the principle of the sun-dial, he worked away without the aid of good books or of a teacher, and at the age of 11 or 12 years seems to have practically found for himself how to make dials for any latitude. He procured some old books on navigation and mensuration, and with these curiously unattractive aids taught himself the elements of mathematics. His undoubted ability and taste for mathematics thus became evident to his family and their friends; and he was permitted to go to the University of Glasgow, where he studied, supporting himself, for the most part, by means of his earnings in the summer months, as many a Scotch student does at the present day.

In suitable surroundings he rapidly became a mathematician of a high order, and was chosen Mathematical Master and Professor of Mathematics in the Royal Belfast Academical Institution—a College which filled the most important position in the North of Ireland previous to the foundation of the Queen's University, with its three Colleges in Belfast, Cork, and Galway. It was during the time of his occupancy of this chair that Dr. Thomson's children were born, seven in number; and having early lost his wife, he brought up his children himself, and educated them with

tenderest care, while, at the same time, labouring early and late, he performed the duties of his Professorship, and was able to write text-books on Arithmetic, Algebra, Euclid, Trigonometry, Differential and Integral Calculus, and Geography, including the elements of Astronomy. These text-books were justly celebrated, and were appointed to be used under the National Education Commissioners of Ireland. They are still in use, though the original copyright expired many years ago.

Dr. James Thomson was a teacher of exceptional skill and power. He had the gift of inspiring enthusiasm in his pupils; and his own marvellous devotion to study and unwearying diligence seemed to kindle, even in those not specially gifted, a desire to attain to that standard, at the least, to which care and patience and conscientious work will inevitably lead. He was also far more than a merely learned and skilled mathematician. His books on Arithmetic, Algebra, Geometry, Trigonometry, and Differential and Integral Calculus, show great originality of thought, both in the methods of presenting the respective subjects, and also in the matter presented. He made substantial improvements and advances in the methods for the solution of algebraic equations, and in the investigation of trigonometrical and logarithmic series. Even now, for those who desire to understand and master the subject, his book on Differential and Integral Calculus is one of the best and most interesting, dealing, as it does, with these two branches of the subject together and as a whole, instead of treating the two separately and in two different volumes. It is not, of course, suitable for the purposes of modern competitive examination—perhaps it never was suited for purposes of this sort.

James Thomson, the subject of the present memoir, was the eldest son of this remarkable man. He had two sisters older than himself; and William (Lord Kelvin), the second son, and thus the fourth child in the family, was not quite two years younger than his brother James. The boys never were at school, unless perhaps at a class for writing. Their father, an excellent classical scholar, as well as learned in most other departments of knowledge, himself gave them their early instruction.

The two brothers, devoted to each other from their earliest infancy, slept in their father's room, and were always learning and never weary of learning; and their father was never tired of

pouring out information for his children from his well-stored mind. Their morning readings, their afternoon rambles, their visits to the seaside, were always, and are now to the survivors, recollections of extreme pleasure and interest.

In 1832, when James Thomson was ten years of age, his father was elected to be Professor of Mathematics in the University of Glasgow, and removed thither with his children. Soon after this—in the next session, in fact—James Thomson began attending some of the classes in the University, and subsequently the two brothers passed through the University together. Both were highly distinguished, the two lads usually obtaining the first and second prizes in each of the classes which they attended. At a very early age, also, James Thomson showed evidence of considerable inventive genius. When he was about 16 or 17 years of age he invented a mechanism for feathering the floats of the paddles of paddle steamboats. Steamboats, even on the Clyde, were comparatively novel in those days, and the invention was looked on with much interest by engineers to whom it was shown. Unfortunately, however, from a commercial point of view, another method of accomplishing the same object had been invented and patented only a few months before.

After passing through the University curriculum, James Thomson took the degree of M.A., with honours in Mathematics and Natural Philosophy, at the age of 17.

The question was then considered whether it would be desirable that he should proceed to Cambridge and continue his mathematical studies there. He decided, however, to follow practical engineering, and inquiries were commenced with the view of finding a suitable place where he should serve his apprenticeship as an engineer.

In the autumn of 1840, however, a misfortune happened which probably produced very lasting effects on James Thomson's subsequent life. After the close of the winter session in Glasgow, his father took the four elder members of his family for a tour in Germany. This tour seems to have been of keenest interest and delight to these exceptionally bright young people. Guided by their father's rare intelligence, they saw everything with keen eyes and understanding, and the happy days of over three months formed a lasting memory for each member of the party. During the tour, however, the brothers James and William went for a walking excursion in the Black Forest; and

James seems to have overtaxed his strength, and on his return home he was for a considerable time more or less invalided. In this autumn he went to Dublin, to the office of Mr. Macneil (afterwards Sir John Macneil), who was at that time carrying out important work in bridge construction. He remained but a short time, however, and was obliged, on account of his health, to return to Glasgow. In 1841 he was better, and was for six months at work in the engineering department of the Lancefield Spinning Mill.

In 1840 a new departure was made in Glasgow University, which proved of great importance, and which has had far-reaching influence in the practical teaching of engineering in this country. This was the foundation, by Queen Victoria, of the first Chair of Civil Engineering and Mechanics in the United Kingdom. The first professor was Lewis Gordon, who was succeeded fifteen years later by Macquorn Rankine. James Thomson, at home and in delicate health, attended Professor Gordon's classes in engineering, and was busy with inventions of various sorts, and particularly with a curious boat, which, by means of paddles and legs reaching to the bottom, was able to propel itself up a river, walking against the stream.

In 1843 his health was so far recovered that he was able to commence his engineering apprenticeship in a more regular way. He had already made himself master of the theory of engineering, but it was necessary that he should collect drawings and make himself acquainted with the practice of the best makers. Accordingly he went first, in a temporary way, to the Horsley Ironworks, at Tipton, Staffordshire, but soon after, in August, 1843, he commenced work with Messrs. Fairbairn & Co., at Millwall, London. This engagement was considered in every way a matter of gratification. The Fairbairns were regarded as the first millwrights and among the first engine-makers in Britain. They had works both at Millwall and at Manchester, and in October, 1844, James Thomson was transferred to the Manchester works, where he was to see from the beginning the construction of an engine of considerable horse-power.

During the months which he spent at Millwall he was also at work on an invention in furnace construction for the purpose of prevention of smoke. The fire bars were to be tubes, with water circulating through them, and the gases of combustion were to be taken downwards through the furnace instead of upwards.

Unfortunately he was not able to remain long at Manchester. In December, 1844, he returned home ill, and this illness was the commencement of a period of delicate health which lasted for many years, and, indeed, produced a permanent effect on his whole life. He seems to have suffered from irregularity of the heart's action, and, indeed, was told by some of the physicians who were consulted that he was affected by serious heart disease. The illness and the unfavourable medical report prevented his being able to pursue his professional work with the vigour of his age. He was unable to carry on the active duties of a young engineer in a factory, and during the next few years he spent much of his time in work which did not involve bodily fatigue, and was busy with inventions of various kinds. He gave much attention to various machines for utilising water-power. Even in 1841, previous to the commencement of his engineering apprenticeship, he had thought on and devised a horizontal water-wheel, but had put this, and other matters of a similar nature, aside to prevent interference with more regular business. He now, however, found time to push forward the work of invention, and it afforded him much gratification to emerge from an enforced inactivity and employ himself in the design and construction of models connected with the inventions then in progress. Work of this sort employed him for several years.

He constructed a horizontal water-wheel, which he named a Danaide, being an improvement on the Danaide of Manouri Decto; and, somewhat later, after much investigation and research, he invented a wheel which, from the nature of its action, he called the Vortex Water-Wheel. This form of wheel was patented in 1850. It was an important advance on water-wheels of previous construction. The moving wheel was mounted within a chamber of nearly circular form. The water, injected under pressure, was directed by guide blades to flow tangentially to the circumference of the wheel, and was led thence through the wheel to the centre by suitably formed radiating partitions. Thus the water yielded to the wheel its kinetic energy derived from one-half of the fall, and its potential energy from the other half, by pressure on the radial partitions as it passed inwards to the centre, whence it quietly flowed away in the tail-race. A considerable number of these wheels were designed by him for various factories, and for different purposes. They were made and supplied by Messrs. Williamson Brothers, of Kendal, and gave much satisfaction.

In 1847 his mind was also busy with a question, to which at a later date he gave much thought and labour, and to the solution of which he made contributions of great importance. On April 5th of this year there appears a memorandum in his handwriting:—"This morning I found the explanation of the slow motion of semi-fluid masses, such as glaciers."

In 1848 a great improvement in his health took place. It was made clear that the opinion which had been given, that he was affected with serious heart disease, was erroneous. A new treatment was prescribed of a more invigorating kind. With the relief from anxiety and from the lowering diet, considerable amelioration as to his health was rapidly manifested.

In the next year, however, he and his brother and sisters suffered the loss of their father, to whom they were all devotedly attached. Dr. Thomson was seized with cholera, which raged in Glasgow in 1848. He recovered from the attack; but a fever which followed it proved fatal, and he died in the middle of January, 1849. Seldom has there been a more devoted family; seldom a father who made himself more absolutely in sympathy with his children. The blow was in a measure unexpected. It was a calamity to all the children, and the shock fell heavily on the somewhat invalided eldest son.

During 1848 his first three important scientific papers were published. The first of these was on "Strength of Materials as influenced by the Existence or Non-existence of certain mutual Strains among the Particles composing them." The second was a remarkable paper on "The Elasticity and Strength of Spiral Springs and of Bars subjected to Torsion." In this paper the action of the spiral spring was explained, and important principles connected with the subject of torsion were brought forward. These were published in the *Cambridge and Dublin Mathematical Journal*, November, 1848.

The third was, perhaps, yet more remarkable. It was contributed to the Royal Society of Edinburgh, and was on "The Parallel Roads or Terraces of Lochaber, Glenroy." These remarkable *terraces* or *shelves* had attracted much attention. Darwin, Lyell, David Milne-Home, Sir G. Mackenzie, Agassiz, Sir Thomas Dick Lauder, and others, had discussed the causes of their formation. James Thomson, however, gave in this paper what is now the accepted explanation.

Curiously enough, Professor Tyndall seems not even to have

known of the existence of the paper when he gave his admirable exposition of this wonderful natural formation, at the Royal Institution in 1876. He attributes the explanation of the parallel roads to Jamieson, 1863; whereas the whole theory had been given, in the paper just mentioned, by James Thomson, in 1848, with details as to necessary climatic circumstances not noticed by Tyndall.

In January, 1849, he communicated to the Royal Society of Edinburgh a paper of great importance, which was printed in the *Transactions* of the Society, and was afterwards republished, with some slight alterations by the author, in the *Cambridge and Dublin Mathematical Journal*, November, 1850. The title of this paper was "Theoretical Considerations on the Effect of Pressure in lowering the Freezing Point of Water." The principles expounded in this paper were afterwards, in 1857, used as the foundation of his well-known explanation of the plasticity of ice; and later, from 1857 onwards for several years, the whole subject afforded him much food for thought, and extensions and developments in various directions followed. The paper of 1849 was of great intrinsic importance. By the application of Carnot's principle, an absolutely unsuspected physical phenomenon was discovered and predicted, and the amount of lowering of the freezing point of water was calculated. The existence of the phenomenon was shortly afterwards experimentally tested and confirmed by his brother, Lord Kelvin, and the numerical amount verified.

But the paper has yet another title to interest, which is not so generally known. In it, for the first time, Carnot's principle was stated and Carnot's cycle described, in words carefully chosen so as not to involve the assumption of the material theory of heat, or rather, as Thomson himself puts it, the supposition of the "perfect conservation of heat."

For the sake of clearness it may be well to leave here, for a moment, the chronological order of James Thomson's life, and to explain briefly the subsequent development of the ideas first disclosed in this paper of 1849.

Forbes had discovered, by observations and experiments on the Swiss glaciers, the property of plasticity in ice. The fact of plasticity in ice was at first doubted; but it was afterwards admitted, and various explanations were offered of this property, so remarkable in a brittle and, above all, crystalline substance like ice.

In this connection Faraday called attention to the freezing together of two pieces of ice placed together in water; and from this arose a partial explanation by Tyndall, under the designation of "Fracture and Regelation." But this theory, and even the not logical juxtaposition of the two words, did not satisfy James Thomson. There was nothing to show why or how re-union (or "regelation") should take place after fracture. He saw, however, that an extension of his own previous principle of lowering of the freezing point by pressure allowed him to apply it to the effect of distorting stress on solid ice, and gave a perfect explanation of all Faraday's observations and experiments on the union and growth of the connecting link between two pieces of ice under water, pressed together by any force, however small.

By this extended thermodynamic principle he also accounted for the yielding of a mass of ice crystals (dry snow, for instance) at *temperatures lower than the ordinary freezing point.* He demonstrated that the mutual pressures must melt the ice at and close around the points of contact; and that, when there is relief from the internal stress by this melting, the low temperature of the main solid mass, together with the extra cold due to the latent heat required for liquefaction of the yielding portions, cause the melted matter to re-freeze in the places to which it has escaped in order to relieve itself from strain. The substance, in fact, which is made liquid or semi-liquid at a temperature lower than zero C., under pressure or strain, passes away in this chilled condition to a place where it is relieved; and being thus relieved it solidifies. Thus a complete explanation, based on a demonstrated physical principle, was offered of the phenomenon.

Thomson's explanation did not, certainly at first, commend itself thoroughly to Faraday. A very interesting correspondence between them ensued; and Faraday made a number of beautiful and interesting experiments, with the object of showing that the placing of two pieces of ice on opposite sides of a film of water (between them) would give rise to the conversion of the film of water into ice, and cause the union of the two pieces of ice, the principle being that of the starting of crystallization in a supersaturated solution by means of a crystal of the solid. James Thomson, however, showed that, in the experiments adduced by Faraday, pressure between the ice blocks was not absent. For example, in an experiment with two pieces of ice, with a hole through each, mounted on a horizontal rod of glass, he pointed

out that the capillary film of water between the slabs draws them together with not inconsiderable mutual pressure, and hence the freezing. Thomson further showed that, when two pieces of ice are brought to touch each other at a point wholly immersed under water, and thus free from capillary action, the most minute pressure pushing the two together causes the growth of a narrow connecting neck, which may be made to grow by continued application of the pressure; while the application of the smallest force tending to draw the two asunder causes the neck to diminish in thickness, and finally to disappear.

In later years James Thomson further developed the theory of 1849. He showed that stresses of other kinds than pressure equal in all directions can relieve themselves by means of local lowering of the freezing point in ice; and he showed, by theory and by experiment, that the application of stresses may assist or hinder the growth of crystals in saturated solutions. Some of these conclusions are of such importance that they deserve to be better known. The title of the paper in which the last-named results were given is, "On Crystallisation and Liquefaction as influenced by Stresses tending to change of Form in the Crystals," 1861.* It included the amended and extended theory of the plasticity of ice.

In 1850 James Thomson was engaged in perfecting his design for the Vortex Water-Wheel. He had soon some orders for the wheel; and in 1851 he took the important step of settling down as a civil engineer in Belfast. Possibly his choice of this place was influenced by the fact that one of his sisters, to whom he was greatly attached, now married to Mr. William Bottomley, an old pupil of her father, was living close to Belfast, and that during part of the period of his indifferent health he had paid her a long visit.

His business grew by degrees. His health improved; and we find him occupied in the next two or three years with scientific investigations as to the "properties of whirling fluids." This led to improvements in the action of blowing fans on the one hand, and on the other to the invention of a centrifugal pump and to improvements in turbines, which were described to the British Association at the Belfast meeting, held in 1852. At this meeting also he described "A Jet Pump or Apparatus for drawing up

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* "Royal Society *Proceedings*," December 5th, 1861.

Water by the Power of a Jet;" and these investigations led to the designing, on the large scale, of pumps of this kind. Some of these pumps have done important work in the drainage of low lands at places where a small stream, capable of supplying the jet, can be found in the immediate proximity. His investigations on the mechanics of whirling fluids again led to the design of great centrifugal pumps, the largest of which are now at work on sugar plantations in Demerara.

It will thus be seen that he was giving much attention to water engineering; and in November, 1853, he became Resident Engineer to the Belfast Water Commissioners, a post which he occupied till the end of 1857.

Meantime he was married, in December, 1853, to Elizabeth, daughter of the late Mr. William John Hancock, J.P., of Lurgan, County Armagh, and sister of Dr. Neilson Hancock, Professor of Political Economy in Belfast, and well known as one of the ablest Irish statisticians. This marriage was a source of great happiness to all Thomson's relations. His wife, devoted to every minutest interest of her husband's life, survived him just one sad week.

In this year (1853) he was appointed Professor of Civil Engineering and Surveying in Queen's College, Belfast. He became fully occupied with the duties of his professorship, and gave up his office and business as a civil engineer, except for the connection which he retained with his former clients, and for business in consultation.

The period of his life in Belfast was one of great happiness and interest. With a natural gift for teaching, he took the keenest pleasure in preparing and perfecting his College lectures. He had also a moderate, but not too onerous, business as a Civil Engineer. He was surrounded with friends, both among the professors in Queen's College and among the residents of Belfast and the neighbourhood, and he gave numerous interesting papers on various scientific subjects to two local societies—the Belfast Natural History Society and Belfast Naturalists' Field Club.

Among his most intimate scientific friends may be mentioned the late Professor Andrews, of Belfast, in whose researches Thomson took the keenest interest; also, Mr. John Purser, Professor of Mathematics; and Dr. Everett, Professor of Natural Philosophy. With Dr. Andrews and Professor Purser the discussions on scientific questions were of very frequent occurrence, and a great source of enjoyment to all three.

According to the arrangement of the Queen's University in Ireland, the Professors of the three Colleges were in the habit of meeting in Dublin, at least twice in each year, for the examination for University degrees and University prizes and distinctions. Here fresh acquaintances or friendships were formed; and, as many of Mrs. Thomson's relations resided in or near Dublin, these periodical visits were also a source of much interest and happiness. Visits also to his brother William in Scotland were always among his keenest pleasures. His mind was incessantly engaged on scientific pursuits and speculations, and an opportunity of discussing with his brother the various questions which presented themselves was always eagerly sought.

This pleasant life in Belfast continued till the year 1873, when, after Professor W. J. Macquorn Rankine's death, James Thomson was appointed by the Government to be Professor of Engineering in the University of Glasgow. The attractions of Belfast and of his many friends there were great, but in connection with the Glasgow Chair there were considerable material advantages which could not be overlooked; and, perhaps outweighing all other considerations, was the great desire to be with his brother. Accordingly, having been successful in his candidature, he removed with his family—his wife, two daughters, and a son—to Glasgow, in October, 1873, and there, among many friends of his youth, and with friends of a younger generation growing up around, he soon became thoroughly at home. His whole energies were spent on teaching, and on scientific research and speculation. He only retained business connections as a Civil and Mechanical Engineer with two or three of his old clients, for the most part, indeed, resident in Glasgow.

His professorship in Glasgow he held till the summer of 1889. Some months earlier a great misfortune happened to him, in the partial loss of the sight of both eyes. This was a most sad affliction, giving him the keenest distress while the illness was in progress, and before it could be known how far it would proceed. The malady proceeded so far that it became impossible for him to read more than a few words, and it was, of course, necessary for him to resign his professorial work. Happily, however, he retained more or less of his eyesight till the end of his life; and as he became more accustomed to the condition of his eyes, he was better able to make use of what remained to him of sight, and was able to move about freely with little assistance, and even to read and

write a little, and to make on a large scale the diagrams which he used to illustrate his Bakerian Lecture on "The Grand Currents of Atmospheric Circulation."

His death was almost sudden, and was the beginning of a sadly tragic time in the family. His age, in May, 1892, was 70, and his health had, indeed, become rather frail. His wife had also been for a considerable number of years in a feeble condition of health, and their second daughter, a young lady of remarkable power of mind and talent in art, had been an invalid almost from her childhood, and was tenderly watched over by all her family. By a strange fatality, one week saw all three laid upon a bed of severe sickness from cold and inflammation of the lungs. In the next week the father, then the sorrowing daughter, and, lastly, the mother, were gone. To all the friends, and, above all, to the daughter and the son who were left, it was an unparalleled bereavement.

It is not possible in the limits to which this notice must be confined to refer to all James Thomson's papers, nor to give a complete list of the many subjects which occupied his attention. Already some of his contributions to thermodynamics have been mentioned, but it must be further remarked that during the portion of his life which was occupied with teaching he gave great attention to this subject, endeavouring to improve the nomenclature and the modes of expression of the various principles and propositions connected with it, and to simplify methods of explanation and of statement.

Another very remarkable contribution to thermal science and thermodynamics was his extension of Andrews' discoveries on the subject of the continuity of the liquid and gaseous states of matter. Thomson's mode of conception of the whole subject was perfectly new and most important. It led him to the construction of a model, in three dimensions, to show continuity above the critical point and discontinuity below in the mutual relations between pressure, volume, and temperature of such a substance as carbon dioxide, under continuous changes of pressure, and volume, and temperature. The model itself threw a flood of light on the question; and the imagining of the extension of the three-dimensional surface so as to include an unstable condition of the substance, partially realisable and even well known in the phenomenon of a liquid passing its boiling point without forming vapour, and of similar unstable conditions, was an advance in the

theory of this important question, the consequences of which are not even now completely realised. This extension carried the question in completeness far beyond anything thought of by Faraday and Andrews; and the verification of Thomson's theories on this subject has proved a fruitful field for experimental investigations by many workers.

Another subject of great importance to which Professor James Thomson devoted much thought and attention was that of safety and danger in engineering structures, and the principles on which their sufficiency in strength should be estimated and proved. He made more than one weighty communication on this subject to engineering societies, and on his appointment at Glasgow, in 1873, he made it the subject of the Latin address which it is the custom for a newly-elected professor to read to the Senate of the University of Glasgow. An address in English on the same subject became his inaugural lecture to the students of his class in engineering. In 1884 he became President of the Institution of Engineers and Shipbuilders in Scotland, and this subject formed one of two main themes in his opening address; and in 1885 his opening address to the same Institution was almost wholly occupied with the extension and elaboration of this subject, which he deemed to be of paramount importance to practical engineers.

When he took up the question, about 1862, he felt that ordinary engineering practice as to the testing of structures—boilers, for example—was both illogical and unsafe. He considered that the tests usually applied were quite insufficient to permit of an engineer feeling justified in risking the lives of men and the property of his employers to the dangers of breakdown. It was then a common opinion that severe testing should not be applied lest the structure should be weakened by the test itself; but Thomson denied that the test does weaken the structure if the structure be good, and pointed out that the real reason for not applying a proper test was frequently fear lest the structure should be found far inferior in strength to that which it was intended to have. The truth of Professor Thomson's contentions is now admitted by the most eminent engineers, and the best engineering practice has, happily, undergone a thorough reform in this respect.

Certain geological questions possessed much interest for James Thomson. We have seen how, at an early age, he investigated the Parallel Roads of Glenroy; and on many subsequent occasions

he examined with great care the places where he chanced to be residing, and found and described glacier markings. He traced out, on more than one occasion, specially interesting features of the ice action, endeavouring to determine, by means of an examination of the markings, details as to the motion of the ice, whether in the form of glacier or in the form of icebergs taking the ground in shallow waters.

His attention was also directed to the jointed prismatic structure seen at the Giant's Causeway, in Ireland, and elsewhere. No satisfactory explanation of this remarkable phenomenon had been given. The old theories, involving a supposed spheroidal concretionary tendency during consolidation in the material, seemed quite untenable. He examined with great care the appearance presented on the surfaces of the stones, and concluded that the columnar structure is due to the shrinking and cracking during cooling of a very homogeneous mass of material. The cross-jointing he considered to be in reality due to conchoidal fractures, commencing at the centre of the column and flashing out to the circumference.

A very interesting subject, and one of very high importance to which Professor Thomson gave great attention, is the flow of water in rivers. He investigated with great care, and from a theoretical point of view, the origin of windings of rivers in alluvial plains, and his conclusions were published in the "*Proceedings* of the Royal Society," May 4th, 1876. Later in the same year he constructed, in clay, on a table, a model with which he investigated the movements of the different parts of the water in passing round the bends in this artificial river; and, finally, he made a large wooden model of a river flowing on a nearly horizontal bed, with many bends and various obstacles. By aid of fine threads, small floating and sinking bodies, and coloured streams of fluid coming from particles of solid aniline dye dropped into the channel, he was able to follow from point to point the movements of the fluid, and thus to give not only beautiful and striking ocular evidence of the truth of his early conclusions, but also to extend his theory. Papers on this subject were communicated to the Royal Society in 1876, 1877, 1878. The paper of the last-named year was entitled "On Flow of Water in Uniform Regime in Rivers and in Open Channels generally." It contains a very clear and striking account of what does actually occur in the motion of a river down its inclined channel, and, in particular, of the fact, which seems well

ascertained, that the forward velocity of the water in rivers is, generally, not greatest at the surface, with gradual abatement from surface to bottom (which would be required under the conditions supposed in the laminar theory), but that, in reality, the average velocity down stream is greatest at some depth below the surface, from which place up to the surface there is a considerable decrease, and down to the bottom a much greater decrease. This phenomenon he showed very clearly to be due to the rising of masses of slow-going water from the bottom by directing action of bottom obstacles. These masses of slow-going water, when they reach the top, spread themselves out, and, mingling with the quicker surface water, give to it, on the whole, a less rapid movement than it should otherwise possess. The paper, as a whole, forms a masterly exposition of this important subject.

Finally, in this brief summary must be mentioned the paper which was made the Bakerian Lecture for the year 1892. In 1857 Professor Thomson read a paper to the British Association on "The Grand Currents of Atmospheric Circulation." It appears that his attention was first called to this subject, when, during the period of his early delicacy, his father asked him to look into the question of the Trade Winds, and write a short account of this atmospheric phenomonon for a new edition of Dr. Thomson's "Geography," which was then in preparation. This was done, but young James Thomson found so little satisfaction in the information and theories which he then studied for the purpose that his mind was keenly directed to the question, and in 1857 he himself had formed a theory, which he expounded to the British Association.

The subject was before his mind during the rest of his life; and though, on account of other pressing work, the complete publication of the theory was from time to time deferred, yet it was always his intention to return to the question. When, in the last years of his life, the affliction of partial blindness came upon him, and when he had partially recovered from the first depressing defects of finding himself thus sadly crippled, he set himself in his enforced leisure to complete this work, and, with the assistance of his wife and daughters, to produce the important paper which was read before the Royal Society on the 10th of March, 1892. In this paper a historical sketch is given of the progress of observation and theoretical research into the nature and causes of the

trade winds, and other great and persistent currents of atmospheric circulation. Previous theories are discussed and criticised, and their merits duly recognised, the theory of Hadley, in particular, being shown to be substantially true. A much more complete theory is then expounded in full detail, and charts and diagrams in illustration show the nature of the aërial motions.

Here this memoir must close. There are many papers of Thomson which have not even been alluded to in it. Nor is it possible or necessary for the present purpose to refer to all the subjects to which his ever-active mind directed itself. A character so truly philosophic it is very rare to meet. His was a singularly well-ordered and well-governed mind. It was, if one may venture to say so, almost too philosophical and too well-governed for the business of every-day life. He could scarcely realise a difference between greater and smaller error or untruth. Great or small error and untruth were to be condemned and resisted; and, perhaps, in the matter of public business, and in this hurrying nineteenth-century pressure, there were those who, thoroughly conscientious themselves, could not yet feel perfect sympathy with his extreme and scrupulous determination to let nothing, however small, pass without thorough examination and complete proof. To temporise was not in his nature; and this extreme conscientiousness gave rise to a want of rapidity of action, which was, perhaps, the only fault in a singularly perfect character.

Purity and honour in word and deed and thought, gentleness of disposition, readiness to spend his labour, his time, his mental energies for others, and for the good of the world in general—all were conspicuous in his life, both in public and in private. He could not even understand why any one should make a hardship of spending himself or his goods for the benefit of others. When, on the last night of his illness, the frail body had almost lost connection with the active spirit, even in the midst of much wandering the philosophic habit of his mind seemed never for a moment to be lost. Though doubtless incoherently, his views and thoughts about many scientific questions were gone over and discussed; and to those who, from previous knowledge, had the clue to enable them to follow, there were many matters referred to by him which were full of interest.

Professor Thomson was elected Fellow of the Royal Society in 1877, and he received the honorary degree of D.Sc. from the

Queen's University in Ireland, and of LL.D. from his own University of Glasgow and from the University of Dublin.

He was early a member of the Philosophical Society of Glasgow, having been admitted, as James Thomson, Junior, in 1841. He seems to have retired on leaving Glasgow in 1844; and he was re-elected on the 18th February, 1874. On this evening he delivered a lecture on "The Gaseous, the Liquid and the Solid States of Matter." In 1875-76 he gave a short paper of some importance on "The Vena Contracta;" and this paper was supplemented by a communication from Sir William Thomson, which contained a letter from the late Mr. William Froude, F.R.S., on a special form of the Vena Contracta, and a review of Newton's conclusions on this subject. Papers were also contributed by Professor Thomson to the Philosophical Society, in 1878, on "House Drainage," and on February 15th, 1882, "On a Changing Tesselated Structure in certain Liquids." The latter paper gave an account of curious phenomena sometimes observed in soap solutions and liquids of a similar character.

Professor Thomson was elected a Member of Council in November, 1874, and served for the customary three years.

In November, 1874, he was elected Member of the Institution of Engineers and Shipbuilders of Scotland, and became a Member of Council in 1875. In 1877, he was elected Vice-President, and, in 1884, was chosen as the President. His opening addresses to the Institution in 1884 and 1885 have been already referred to. He took great interest in the Institution, and frequently took part in the discussions which followed the reading of papers at its meetings.

XVIII.—Mr. John Jex Long.

After being a Member of the Philosophical Society for upwards of thirty years, Mr. John Jex Long passed over to the majority on 12th June of this. year, at his residence in Doune Terrace, Kelvinside. He was one of the sufferers in the dreadful disaster to human life at Crarae Quarry, Lochfyneside, in the year 1885, and he was never the same man afterwards. The present writer was also a sufferer by the same disaster, though not to the same extent as Mr. Long, but he forbears to enlarge upon it with its unpleasant memories. The deceased belonged to St. Germains, Lynn, Norfolk, where he was born, in July, 1825, so that he was almost exactly sixty-eight years of age at his death. After serving an apprenticeship to the watchmaking trade he came to Glasgow and took the management of the business of his aunt, Mrs. Benjamin Musgrove—ironmongery, gunmaking, and cutlery,—which was carried on at No. 46 Trongate. That was in 1847, and early in the following year, when the destructive Glasgow riots broke out, his warehouse was sacked, and he was sworn-in and served as a special constable.

Four years later, in 1852, Mr. Long acquired the Greenvale Chemical Works, Duke Street, and then began the great business in which he was so very conspicuous for many years as a Glasgow industrialist—namely, that of the manufacturing of lucifer matches, in combination with sawmilling and the timber trade. In the introduction of that household commodity, the lucifer match, at a popular price, Mr. Long was a genuine pioneer. He prosecuted the business on a very extensive scale on his own account till the year 1881, and in his hands the matchmaking industry became quite famous in Glasgow. He had an extensive laboratory established within the works, the result being that he was enabled to institute important improvements in several of the processes, and within the dangerous portion of the works everything that science suggested was done for preserving the health and ensuring the safety and comfort of the work-people, of whom there were, at one time, between 300 and 400 employed within the gates. Mr. Long not only effected valuable improvements in the purely chemical department of his works, as in the preparation of chlorate of potash, but he was also enabled to

introduce some excellent labour-saving appliances in the machine department where the timber was transformed into match-splints, for he was exceedingly ingenious and brimful of useful mechanical inventions and devices. He was a good customer to the Patent Office and to the local patent agents. One of his patented inventions was the "Rowley" machine (named after one of his sons), by means of which, and with the aid of one boy, the manufacturing capacity of the works was brought up to fourteen millions of finished matches per day.

The sawn timber trade carried on at his works by Mr. Long assumed large dimensions. His high reputation for just and honourable dealing, and his liberal method of conducting business, brought him numerous customers from a wide district, and his able and enterprising management was always conspicuous in retaining them. He was one of the first to introduce the system of sawn timber sales by monthly auctions—a system which was much appreciated, as it thoroughly met a popular want.

In the year 1881 Mr. Long was induced to dispose of his business to the Bell & Black Match Company (Limited), along with all his machinery and patents; and in 1885 the whole concern along with many others of the kind throughout the kingdom, was sold to Bryant & May (Limited), of London, and Mr. Long then retired from active business.

From the time of the Crarae Quarry disaster, the year of his retiral from business, his health continued to fail, more or less, and in 1890 he had such a severe illness that he was not expected to recover; but he managed to pull through sufficiently to be able to get out into the fresh air for a little every day. Within the next two years he lost two of his sons and his own wife, and such repeated bereavements told very severely upon his already much-weakened physical condition, and he gradually sank till he was overtaken by a shock of paralysis, which rendered him unconscious, and carried him off within a few hours, on the day already mentioned. He has left a family of two sons and three daughters. One of the former is a timber merchant and sawmiller, and one of the latter has attained some distinction as a novelist.

Mr. Long became a Member of the Philosophical Society in 1862, and for many years he took a deep and active interest in its welfare and its proceedings. He frequently took an intelligent part in discussions on subjects with which he had some acquaintance. During the triennial term, commencing in Session 1878-79,

he served as a very useful Member of Council. He also took a lively interest in the Chemical Section in its early history, and on one occasion he made a communication to the Section on the metallurgy of lead, a subject which he had studied in one of the lead-mining districts of Cumberland. Mr. Long interested himself generally, in various branches of Science, more especially those which had important industrial developments. In that connection it may be mentioned that he was a Member of the British Association for upwards of twenty years, having joined that great scientific organisation at the Edinburgh meeting of 1871, when Lord Kelvin, then Sir William Thomson, was President. Our deceased fellow-member was an enthusiastic votary of the art of Photography many years ago, and he even became President of the Glasgow Photographic Society, an office which he filled at the time when a very successful exhibition of photographic pictures was held in the Corporation Galleries.

J. M.

XIX.—*On the Planning of Public Libraries.* By G. Washington Browne, Assoc. R.S.A., Architect, Edinburgh.*

[Abstract of Paper read before the Architectural Section, 30th January, 1893.]

The principles underlying the planning of public libraries are not yet universally acknowledged, and the requirements have not yet been reduced to a code, and it appeared to me that any contribution, however imperfect or inadequate, which might tend towards the establishment of such principles, or lead to a clearer appreciation of the requirements of a public library, might be not without interest to the members of the Architectural Section of the Philosophical Society, in a town which had not yet seen its way to adopt the Public Libraries Act, and which will thus have the opportunity, when its day comes, of improving, after what has been already done elsewhere.

It is no part of the task I have set myself to-night to discuss the *rationale* of the public library, nor do I think such advocacy necessary. Nobody, I suppose, could be found to-day with the hardihood to adopt the opinion of Sir Anthony Absolute, and maintain that "a circulating library in a town is an evergreen tree of diabolical knowledge."

Carlyle, forty years ago, put the question in a way which admits of but one answer, when he asked, "Why is there not a Majesty's library in every county town? There is a Majesty's gaol and gallows in every one;" and, following this up, Mr. Greenwood, in his book upon "Public Libraries," says, "The State has not done everything for the people that it is called upon to do, when it has provided a gaol, a workhouse, a lunatic asylum, a policeman, and a share in the common hangman."

For our purpose, it will be sufficient to regard the establishment of public libraries as *un fait accompli;* and by public libraries, I mean, not the great national consulting libraries, but the municipal library, with the popular lending department, newspaper room, magazine room, and, if you like, boys' and

* Owing to the late arrival of Mr. Browne's MS., the Editor found it impossible to put this communication in a more suitable place—in the body of the volume.

ladies' rooms—in fact, the library of the people established under the Act; and to the planning and equipment of these I shall confine myself throughout my paper.

In considering the subject I shall endeavour to set forth the requirements of such a library, and refer to a few typical plans (displayed upon the walls) as favourable examples of how these requirements have been well met. They are all plans of libraries actually executed, and in each case the design adopted was placed first in competition. It may seem something very like vanity to place my own design for the Edinburgh Library in such a group, but the eulogies that have been passed upon it by disinterested writers, and my familiarity with the working out of its conditions and requirements, must be my excuse for its position in this group, and the frequent references I must perforce make to it throughout the paper. And here, let me say, that, thanks to Mr. Carnegie's munificent gift, this library is planned upon a more liberal scale than is usual in buildings erected under the Act.

From the outset the architect has to consider that he has two sorts of accommodation to provide for—one, of the public who are to use the books; the other, of the books themselves, with which may be linked the staff who are their guardians. In all public libraries there are three distinct departments for the accommodation of three different classes of literature, and which, one might say, are used by three different classes of the community. There are the news room, for newspapers daily and weekly, and the more popular of the weekly and monthly journals and magazines, and frequented chiefly by the artisan and industrial class, employed and unemployed; the lending library, used by the general reader, male and female, for borrowing and returning books, for what may be called household reading; and the reference library, the volumes in which can only be consulted—not borrowed—and used chiefly by the student, the *litterateur*, and the specialist. Besides the bound volumes under custody on the shelves, the current numbers of the higher class of professional, artistic, and scientific journals, and the monthly and quarterly reviews, are generally displayed upon the tables of the reference department, and are available to the reader without application to the librarian.

The purposes for which the public use these three departments determine their nearness to or remoteness from the

principal entrance. The lending department, in which no reading is done, but in which the work is merely that of borrowing, returning, exchanging, and renewing volumes, and which, in the interest alike of the public and the staff, should be done speedily, is consequently placed as near the entrance, and in as direct a line with it as possible. The news room, into which people drop for half-an-hour, to read a newspaper or a journal, may be further removed from the entrance; while the reference room, used for the more serious purposes of study and research, should be most remote from the entrance, to secure it against the noise and stir of the traffic to the other departments; but the approach to all the departments from the principal entrance must, of course, be obvious and easy, not tortuous nor obscure. And as the traffic to and from all the departments converges in the entrance hall, the latter must be spacious and well lighted. Immediately on entering the hall, the visitor should be directed by door-plates or finger-posts to the department which he wishes to reach. In buildings, therefore, in which all three departments are upon one floor, the lending room would preferably be in the centre, opposite the entrance, with the news room upon one side, and the reference room upon the other.

Though the question of orientation does not enter largely into the subject of library planning, one would naturally, where the choice is open, place the news room upon the south side, where the sun, entering through the windows, would have no valuable bindings to destroy, and would not so much disturb the cursory reader of a magazine as it would a more serious student in the reference library.

Such an arrangement, while simplest for the public, is also bad for the staff. The librarian would be, for the most part, engaged in the lending department, and from his service counter can not only command the entrance hall, but by glass screens can supervise and control the reading rooms on either side, as at Brechin and Southampton.

But it is only in the case of the smaller libraries, or on exceptionally large sites, that all three departments can be placed upon one floor. If two departments only can be placed upon one floor, then let the lending library and the news room be upon the entrance level, and the reference room above, as in Chelsea; and if the smallness of the site or the largeness of the rooms permit of only one department upon each floor level, then let the lending room be

upon the street level, the news room upon the first floor, and the reference room upon the second floor up—unless, indeed, you have a site like that in Edinburgh, where the principal entrance is from a street at a level of 48 feet above the ground upon which the building rests. In this case the lending library is placed upon the entrance level, the news room upon the floor immediately *below* it, and the reference room upon the floor immediately *above* it; the best arrangement possible where the three departments must be upon different floors. Sometimes this disposition of the departments is managed by placing the news room on a semi-basement, a single flight of steps below the entrance level, with the lending room a single flight above the entrance, and the reference room over that again.

The position of the librarian's room is of some importance, and calls for a little consideration. His room should be placed less with reference to the public and more with reference to his staff, a position where he can be conveniently found by his staff, and from where he can readily control them; and if from his room he can see the frequenters of the library without being seen of them, so much the better; but one must remember that the principal librarian is not the hall porter.

The question whether there ought to be separate reading rooms for ladies and for juveniles is generally answered in the affirmative, though the practice is by no means universal, and there is much to be said on the side of the dissenters.

If separate rooms are provided, the juveniles should not be permitted to penetrate the building unnecessarily far beyond the entrance hall, and this room should be in the direction of the news room, where the reading being of a less serious kind than in the reference room, less disturbance would be produced by the noise of the youngsters; while the ladies' room should be placed near to, or *en suite* with, the reference library, both on account of the retired situation, and for convenience in supplying the visitors with the books they may desire to consult.

In addition to these rooms for the public, there must also be provided sufficient accommodation for the working of the institution by the staff, as well as rooms for the members of the staff, committee room, a book-binder's room for repairs, and a cataloguing room. Above all, ample storage accommodation is a necessity upon which every librarian to whom I have spoken has insisted with greater or less vehemence.

News Room.—Coming now to consider in more detail the requirements of each of the three main departments of the public library, we may take the news room, or light literature department, first, as being, perhaps, least complex in its arrangement. This is already mentioned as for daily and weekly newspapers, and for the lighter periodicals. In some libraries separate rooms are provided for these two classes, and you find a newspaper room and a general reading room. I am against such subdivision of departments into separate rooms, involving additional staff and increasing the difficulties of supervision.

The magazine readers are accommodated with tables and chairs, the chairs being ranged along both sides of the table to economise space. The tables, which are the ordinary height of about 30 inches, should be not less than 3 feet broad. At Edinburgh they are made 3 feet 6 inches broad, after careful comparison and consideration. In Birmingham they are as much as 5 feet 3 inches broad, but that is excessive and wastes space. At Leeds they are 4 feet broad. A lineal allowance of 2 feet to 2 feet 3 inches per reader is necessary, and the tables must be spaced at such a distance apart as will allow free passage between the backs of the chairs of adjacent tables.

The result of this opening, with, of course, the necessary access passages along the ends of the tables, is that an area of about 20 superficial feet per reader is absorbed. This is a liberal allowance. In the course of a series of articles upon Public Libraries, in the *Building News* in 1890-91, an area of 15 superficial feet is mentioned as an allowance per reader for the news room. This, I think, is insufficient, and an area of 18 feet per reader is the least allowance that can be made, consistent with a fair degree of comfort to the readers. Of course, this includes the space occupied by tables and chairs. On the plans displayed the figures are:—Edinburgh, 22; Chelsea, 17½; Southampton, 20½; average of these three, 20 square feet per reader. The tables should be arranged at right angles to the windows to allow the light to strike along their length free from the shadows of readers.

The newspaper reader has less consideration shown him than the magazine reader, inasmuch as he is not provided with a seat, but must stand up to his paper. Familiar as we all are with our morning newspaper, I dare say, if asked the size of it, the answers would be as various and as wide of the mark as those usually

hazarded as to the height of a tall hat. The *Scotsman* is 2 feet 3 inches high, and when opened out to the double page, 3 feet 8 inches broad; the *Glasgow Herald* is 2 feet 2½ inches high, and 3 feet 5 inches broad over the double page; while *The Times* is 24½ inches high and 37 inches wide.

These newspapers are ranged upon stands specially designed to receive them, and to which they are attached by Cumming's patent fastener, a clever arrangement, which keeps them firmly fixed in position, and is readily unscrewed for removing the old and refixing the new issue each morning. The desks or sides of the stand upon which the papers rest slope at the angle of 60°, so that, in a double stand, the two sides form, with the base, an equilateral triangle, each side of which is, say, 2 feet 6 inches. An allowance of 4 lineal feet per newspaper should be given, and the length of the stands consequently some multiple of that unit.

The newspaper stands, like the reading tables, should be placed at right angles to the windows, or they may be very conveniently placed, if single construction—that is to say, with one sloping side only, along the wall under the window sills, if the sills are 6 feet above the floor level, which they may with advantage be. When placed in successive rows they should not be spaced closer than 9 feet centres. The spacing at Chelsea is 8 feet, which will just do; at Brechin, 6 feet 6 inches, which will not do; and at Edinburgh, 13 feet 6 inches, to suit the architecture.

The requirements of the general reading room or news room, therefore, are very simple. The chief points are to have a sufficient floor area, 18 to 20 feet per reader. Do not seat the readers too closely at the tables; none less than 24 inches each, and as near 30 inches as possible. Leave the passages and gangways between tables and newspaper stands sufficiently wide to enable any one to pass through without disturbing the readers on either side, and place the tables and stands at right angles to the light.

Lending Library.—We now come to the lending library, the arrangements of which present various points of much interest, which are well worthy careful consideration. The nature of the work carried on in this department is nearly identical with that carried on in the telling room of a bank, the matter changing hands being books instead of money; and I take it that the plan, from my experience, to be most convenient for the one business will be well adapted for the other. Thus, where a large amount of business is to be transacted, the model would be the telling

room in the head office of a bank; and for smaller business, the corresponding room in a branch bank. The former was the model adopted for the lending room in the Edinburgh Library, and the librarian, after two or three years' experience, declares it to be a model lending room, permitting the highest possible efficiency in service. Contrast with this the meagre, narrow, confined spaces, called "borrowers' lobbies," in many English plans, lobbies in which it seems to me physically impossible to carry on the work.

The key to the whole plan of the lending room is the indicator, that most useful of all appliances in a public library, saving the time and the temper of public and staff alike, and enabling the work to be carried on with a smoothness and a quickness otherwise unattainable. I have here a small model of Colgreave's (shown and described), that is in use at the Edinburgh Library, and which possesses, among its other merits, the advantage of being the most compact.

The total height of the indicator as used in ordinary practice is 4 feet, the nett space occupied by the figured pigeon holes being 3 feet 3½ inches. Its length is 15 inches for every 1,000 books recorded, and it is made in 5-feet lengths, each length indicating 4,000 volumes. If these are arranged in pairs, which is probably the most serviceable and economical grouping, they occupy a length of counter of, say, 10 feet 3 inches, allowing a trifle for some kind of wooden case to enclose the somewhat uncouth iron framework—10 feet 3 inches, for a record of 8,000 volumes. Now, experience shows that this is just about the number of volumes that one, or, where there are a number, *each* attendant can serve from with reasonable speed. So that, for each 8,000 volumes, you require a service space which cannot be less than 18 or 20 inches, and this space would probably be sufficient between the pairs of indicators if the applicants came at regular intervals all day long. But, as we find they come at certain hours quicker than they can be served, you have three, four, or half-a-dozen people waiting their turn at each service opening at certain hours, just as you have at the ticket office of a railway station a few minutes before the departure of a train. If the indicators were placed close up to each side of the service opening, those persons waiting their turn would be standing in front of the indicators, completely preventing new comers from seeing whether the books they desired were in or out. Consequently, it is necessary to place the indicators at some distance apart, that they

may always stand free for examination, and this distance cannot well be less than 5 feet. Now, 5 feet, plus the length of the indicators with their frames, 10 feet 3 inches = 15 feet 3 inches lineal of counter for every 8,000 volumes, which is exactly 23 inches, or, as nearly as may be, 2 lineal feet of counter for every 1,000 volumes in the library. This, then, is a most important and valuable factor; and no plan of a lending library can be considered satisfactory which does not provide something very near this proportion of centre space to the number of volumes shelved. As we shall see presently, under favourable conditions this may be reduced to a minimum of 20 inches per 1,000 volumes, but under the ordinary condition of practice the higher figure will be found necessary. As the counter forms the barrier between the public and the staff, you must provide in front of it sufficient space for your public coming and going and passing from one indicator to another with perfect freedom. Behind the counter you must provide space for shelving books equal to 1,000 for every 2 feet lineal of counter, besides free space for the attendant passing to and from the book shelves, the service opening, and the indicator. You cannot get more than 10 volumes in each lineal foot of shelf, taking the average all through, or 20 volumes in the 2 feet of corresponding counter length, and, as the shelves average 10 inches from centre to centre in height, it follows that, to hold 1,000 volumes, you would require the shelving 500 inches, or 41 feet 8 inches high, if it were ranged singly against the wall behind the counter—2 feet lineal of shelving and 2 feet lineal of counter representing 1,000 volumes of books alike on shelves and in indicators, with their accompanying service openings. As this would be a ludicrous, not to say impossible, height, the shelving is generally ranged at right angles to the counter, between it and the wall, as at Edinburgh and Brechin, where there is a liberal allowance of counter space, and ranged in receding rows parallel to the counter, as in Chelsea and Southampton, where the counter space is more restricted. A glance at these plans will show how much more efficient the service must be by the former than by the latter of these two methods.

The height of the shelving above the floor should never be greater than that which permits the books upon the top shelf to be reached by an averagely tall person without the aid of steps or ladders, fixed or movable. All such expedients are objectionable, and result in injury to the books, and also to the shelving, and

sometimes to the person, and should be avoided. The maximum height of the top shelf above the floor should be 6 feet 6 inches, giving a reach under 7 feet, and enabling the range of shelving, with its cornice, to finish within 8 feet high. Within this limit of height you get 8 rows of shelves, and, allowing 10 volumes to the foot in each row, you require 12 feet 6 inches clear length of shelving for every 1,000 volumes, or, in adding 6 inches for the vertical supports and divisions, 13 feet lineal of shelving accessible by hand from the floor, and 2 feet lineal of counter length for every 1,000 volumes in the lending library.

Still adhering to the unit of 1,000 volumes, our next point of inquiry is—what area of floor space in superficial feet is necessary in the lending library to provide accommodation for books and indicators, staff and public, upon the scale just laid down as necessary for efficiency?

I have prepared a table from the plans of the libraries I have selected as good types, and I find the floor space per 1,000 volumes wonderfully uniform all through. The figures are—Edinburgh, 88 superficial feet of floor space per 1,000 volumes; Brechin, 77, Chelsea, 73, or, if corrected as it ought to be by squaring up the space for public, 78; Southampton, 83; and Aberdeen, as originally prepared, 84. This is not a wide divergence, the greatest difference, considering Chelsea to be corrected, being 11, and the average of the figures as they stand being 81 superficial feet of floor space to every 1,000 volumes.

With the view of arriving at the maximum number of volumes it is possible under any circumstances to obtain in a lending library, while providing the requisite length of counter to place the indicators, and sufficient service openings to secure efficiency of service, I have prepared two plans of rooms, each having an area equal to that of the lending room of the Edinburgh Public Library, viz., 42,000 square feet. I have arranged this area into a quadrilateral apartment of the most suitable proportions for each case. In the one instance, as may be seen, I have assumed unrestricted light on all four sides, and have ranged the bookcases at right angles to the walls, and restricted them in height as before, so that every volume is accessible by hand from the floor level. The space for the public is in the centre, and measures 42 feet by 23 feet—a large, free, open space. By this arrangement I obtain bookcase accommodation for 72,000 volumes upon the standard adopted throughout the paper of 10 volumes per lineal

foot of clear shelf, and 8 rows of shelves in height. I obtain also 120 lineal feet of counter, measured along the line of indicators, giving accommodation for the requisite number of indicators, 18 at 4,000 each, and for six service openings of 5 feet each—that is to say, one service opening with space for applicants standing clear of indicators to every three indicators. In the condition already considered, I have taken one service opening for every two indicators, but the nearness of every book under the plan to the attendant would permit of quite satisfactory efficiency with one service opening to three indicators. The figures brought out by this plan, and shown upon the table, are 58 feet superficial of floor space and 20 inches lineal of counter space for every 1,000 volumes.

In another plan I have worked upon the same superficial area of 42,000 feet, and have assumed no light obtainable from any of the sides, but the room entirely top lighted. Under such conditions I have stacked the books in the centre of the room, three tiers high, under a glass roof (as at the British Museum), encircled by the bookcases with the service and indicator counter, and placed the space for the public in the form of a continuous corridor or ambulatory, 10 feet wide, between the counters and the enclosing walls of the room.

By this arrangement I obtain bookcase accommodation for 88,000 volumes, allowing 10 volumes per lineal foot of shelf as before, and taking advantage of three rows of shelves obtained under the counter all round. For this number of volumes I require 22 indicators, and at least half that number of service openings. The counter space obtained is 168 lineal feet, giving exactly that required for 11 pairs of indicators at 10 feet 3 inches each, and 11 service openings of 5 feet each—one service opening for every two indicators, which, in such a plan, involving slower service on account of the time occupied in getting volumes down from the upper tiers, would be absolutely necessary.

The figures brought out by this plan and shown upon the table are 48 feet superficial of floor space, and 23 inches lineal of counter space for every 1,000 volumes.

In both these plans, by which so high results are obtained, I have considered myself wholly untramelled as to dimensions and shape of ground, mode of acess, means of lighting, &c.; indeed, in each case, I have made my own conditions as to surroundings, and, of course, made them the most favourable for my purpose. And while in neither case have I assumed anything either impossible

or unreasonable, it would be but rarely that one would find oneself with so free a hand in actual practice. Consequently, the results so obtained are not the results to be expected in practice, but they may be advanced as the theoretical standard, towards which one's aim should be directed in practice, and below which one need only fall by the limitations of unfavourable or modifying conditions.

I have dwelt at great length upon the lending library, because I feel that it is the department that presents the most interesting problems in the planning of a public library, and is a department which is capable, with all its complexity, of being reduced to a few fixed rules, which I have endeavoured to establish, of floor space, counter space, and shelf space. These once established and recognised, their distribution and application to the varying conditions of site and amount of accommodation required are matters of detail, which the ordinarily skilful architect will successfully apply to each case that he is called upon to deal with.

Reference Library.—I fear I have already occupied too much of your time, and presumed too far upon your indulgence, so that I shall treat the remaining department of the reference library with becoming brevity. The conditions surrounding the reference library are so varied, ranging from what is apparently a single bookcase in Brechin up to a maximum where limit is set only by the sum of the world's literature, that I do not propose to attempt the task of reducing its requirements to please standards, as I have done with the news room and lending room. The first important question that confronts us, in considering the reference library is that of the housing of the books. Shall they be housed in the reference room or in a separate book store. The old time-honoured method is to have them in the reference room, the newer method is to stock them in a store beyond. The latter is, probably, the more scientific method; but, as in the matter of house-warming, one's sentiments cling to the old unscientific open fire, so also one's sentiments cling to seeing the books upon the shelves in the room, public or private, which we call a library. There is certainly an educative influence, combined with an incentive to further reading excited by the presence of the volumes around one, which would be lacking were they absent from the walls, and to stimulate the desire for further knowledge is not the least among the missions of the public library. There is the wall space ready to hand for storing books, and I know of no good

reason why it should not be utilised for this purpose. I think, probably, a combination of both methods is good, and in process of time both will become necessary. Public reference libraries, as we are considering them, are yet in their infancy, and who shall say to what proportions they may not attain. Once the reasonably available hall or other space within the reference room is occupied, and a receptacle to receive the overflow becomes necessary, it is expedient that that receptacle be a properly constructed and lighted book store, and not a dark, dingy, and inaccessible cellar or attic. This has been done in the British Museum Library. The great rotunda, used as the reading room, is lined with book shelves right up to the springing of the dome, and beyond the circular walls are the great stores, constructed as I have already explained. So, in Edinburgh, the solid walls in the arris of the truss, and the spaces between pillar and pier, are set off in bookcases, three tiers high, with access galleries reached by the enclosed circular stairs in the angle piers; but the plans provide for a book store, constructed as at the British Museum, to be erected as an extension whenever the necessity arises. At Chelsea, the original plan of having bookcases on tinplate tiers, with a gallery round the walls of the reference room, was abandoned, and the books were stacked at once in the store behind. In whichever place the books are kept, a standard different from that of the lending library must be adopted in calculating the shelving necessary to accommodate a given number of volumes. The publications found in a reference library range in size from the bijou 32mo. to the stateliest folio, and in thickness from the lean and slender pamphlet to the corpulence of the omnivorous encyclopædia. Upon an average, one cannot count upon more than 7½ volumes per lineal foot of shelf, while the height will average one shelf to the foot—that is to say, that while in the lending library you may reckon upon 12 volumes per superficial foot of shelving frontage, in the reference library you cannot reckon upon more than 7½, or, at the outside, 8 volumes in the same space. In other words, within a given superficial frontage of bookcase, the number of volumes pertaining to a reference library that could be shelved would be on the like proportion to the number pertaining to a lending library that could be shelved within the same frontage as 2 does to 3.

The tables in the reference library should be single, not double, so that the readers sit upon one side only, and all face the

librarian's desk. This affords opportunity for better surveillance, and checks the depredations of the book-ghoul. An allowance of not less than 2 feet 6 inches should be made for each reader at a table. This is the allowance given in some of the best English libraries, as Leeds and Birmingham, and was adopted at Edinburgh. The British Museum reader has the princely allowance of 4 feet 2 inches. The single tables are two feet broad, and should be spaced 3 feet apart. Short tables are preferable to long ones, and special tables, somewhat broader than the single ones, should be set apart for the use of accredited students reading up a special subject, for which they may require several volumes at a time for cross reference. The above principle of planning a reference library, besides offering the amplest opportunities for shelving within the room, affords also excellent bays for the accommodation of the special student.

REPORTS OF SECTIONS.

SESSION 1892-93.

[Received at Meeting of Society, 3rd May, 1893.]

1. Report of the Architectural Section.

This Section held eight Meetings during the Session, at which the following papers were read :—

Monday, 14th *November*, 1892.—Mr. Campbell Douglas, architect, F.R.I.B.A., President of the Section, delivered the Opening Address.

Monday, 28th *November*, 1892.—Mr. Charles B. M'Intosh, "Alexander Thomson" Travelling Student, read a paper on "A Tour in Italy."

Monday, 12th *December*, 1892.—The Secretary, Mr. A. Lindsay Miller, read a paper entitled "Notes on our Cathedral." (The paper was illustrated by lime-light views.)

Monday, 16th *January*, 1893.—Mr. H. C. Shelley, M.I.J., read a paper on "Some Scottish Castles." (The paper was illustrated by lime-light views.)

Monday, 30th *January*, 1893.—Mr. George Washington Browne, architect, Edinburgh, read a paper on "Public Library Planning."

Monday, 13th *February*, 1893.—Mr. John T. T. Brown, writer, read a paper entitled "Notes on Old Glasgow," which was illustrated by lime-light views.

Monday, 27th *February*, 1893.—Mr. John Crichton Fulton, electrical engineer, read a paper on "The Economics of Electric Lighting and Power Transmission." (The paper was illustrated by experiments and lime-light views.)

Monday, 13th *March*, 1893.—Mr. W. P. Buchan, sanitary engineer, read a paper on "Ventilation," which was illustrated by lime-light views.

The thanks of the Section are due to those gentlemen for their kindness.

At the Annual Business Meeting held on Monday, 13th March, 1893, the gentlemen named on p. 279 were elected to office for next session.

A. Lindsay Miller, Architect,
124 Bath Street.

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2. Report of the Geographical and Ethnological Section.

One lecture was delivered on behalf of this Section during the Session at the Ordinary Meeting of the Society on 8th March, by Mr. F. C. Selous, on "Twenty Years of Travel in South Central Africa." Four Meetings were held under the joint arrangement with the Royal Scottish Geographical Society, at which the following papers were read:—

(1.) "A Ride through Persia," by Lieut. D. S. Buist, on 21st December, 1892;

(2.) "The Deserts of Atacama and Tarapaca," by Mrs. Grove, on 13th January, 1893;

(3.) "On an Expedition up the Juba River," by Commander F. G. Dundas, R.N., on 10th February, 1893; and

(4.) "Irrigation and Agriculture in Egypt," by Colonel Justin C. Ross, C.M.G., on 27th March, 1893.

Geo. A. Turner, M.D.,
Secretary.

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3. Biological Section.

4. Chemical Section.

Both of these Sections are for the present suspended by Vote of Council, 26th November, 1890.

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5. Report of the Economic Science Section.

Four Meetings were held during the course of the Session in connection with the Section—

(1) 16*th November*, 1892.—Mr. John Mann, jun., M.A., C.A., read a paper (communicated to the Society) on "Reformed Public-houses: Notes on the Scandinavian Licensing Systems and the

Bishop of Chester's proposals." Much interest was taken in this paper, and a Meeting was arranged for 11th January to give it full discussion.

(2) 11*th January*, 1893.—A short paper on the subject of "Public-house Reform" was read by Mr. J. Y. King, writer, by way of reopening the discussion of Mr. Mann's paper of 16th November *(supra)*.

(3) 22*nd February*, 1893.—Sheriff Mark Davidson, M.A., LL.D., read a paper (communicated to the Society) on "The Elements of Profits."

(4) 17*th April*, 1893.—Mr. William Smart M.A., LL.B., read a paper on "New Wealth, a Study of the Sources of Income."

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6. Report of the Mathematical and Physical Section.

There are no Associates of this Section, and hence there was no meeting during the Session; but several papers obtained through it were read at the ordinary meetings of the Society, and will be printed in the *Proceedings*.

Magnus Maclean,
Secretary.

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7. Report of Sanitary and Social Economy Section.

A Meeting of the Section was held on 27th October, 1892, at which the Office-Bearers for the year were elected. [The list is given on p. 279.] The Council have to record with deep regret the loss they have sustained by the death of one of their number, Mr. W. R. W. Smith.

Following up one of the subjects taken up last year ("The Hygiene of Schools"), a paper was arranged for to be read by Dr. Naismyth, Medical Officer of Fife, on the "Air of Schools." Unfortunately, however, owing to pressure of work, Dr. Naismyth was unable to contribute his paper this Session, but it is hoped the Society may benefit by it next Session.

The President gave a short address to the Society upon "The Ventilation of Rooms."

It was also hoped that other papers might have been contributed, and several interesting subjects were arranged for; but again in these cases pressure of work came in the way.

W. R. M. Church, C.A.,
75 St. George's Place,
Hon. Secy.

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8. Report of the Philological Section.

A Meeting of the Section was held in the beginning of November, 1892, at which the Office-Bearers for the year were elected. [Their names appear on p. 280.]

No papers have been read from this Section during this Session. Some that were expected to be ready in time have been promised for the Session 1893-94.

JAMES COLVILLE, M.A., D.Sc.,
14 Newton Place,
Secretary and Treasurer.

MINUTES OF SESSION.

2nd November, 1892.

The Philosophical Society of Glasgow held its First Meeting for Session 1892-93 on the Evening of Wednesday, 2nd November, 1892, at Eight o'Clock, in the Physiology Class-room at the University, for the convenience of the President, Dr. J. G. M'Kendrick, F.R.S., who occupied the Chair.

1. The Minutes of Meeting held on 27th April, were read and approved of, and signed by the Chairman.

2. The President then proceeded to deliver the Opening Address, which he prefaced by making a few remarks upon the character and work of the late Professor Grant, who was a Member of the Society for upwards of thirty years, as also President, and latterly Honorary Vice-President of the Society. The address proper dealt with "Recent Notions about the Action of a Nerve"—the subject being very extensively illustrated by lantern views, &c. At the close of his address, Dr. M'Kendrick was awarded a very cordial vote of thanks, on the motion of Mr. J. G. Kerr, seconded by Mr. Jolly.

3. Mr. Dugald Bell, F.G.S., and Mr. P. Macgregor Chalmers, F.S.A.(Scot.), were appointed Auditors to examine the Treasurer's Accounts for the year 1891-92.

4. The Chairman announced that all the new Candidates for admission into the Society—twelve in number—had been elected. They were as follow :—

1. Mr. J. G. A. Baird, M.P., Wellwood, Muirkirk. Recommended by Sir John Neilson Cuthbertson, Sir James King, Bart., and Sir Michael Connal.
2. Dr. James Smith, H.M. Inspector of Schools, St. Peter's Lodge, Uddingston. Recommended by Dr. Charles Gairdner, Mr. Walter W. Blackie, B.Sc., and Dr. W. G. Blackie.
3. Mr. William Martin, Shipbroker and Secretary, 116 St. Vincent Street. Recommended by Mr. William Jolly, Sir John Neilson Cuthbertson, and Dr. Henry Dyer.
4. Mr. Horatio Bell, Assistant Engineer, National Telephone Company, Royal Exchange. Recommended by Mr. William Aitken, Mr. Wallace Fairweather, and Mr. John Mayer.

5. Mr. James Murrie, Engineer, 12 Houldsworth Street. Recommended by Mr. Lindsay Burnet, Professor Andrew Jamieson, and Mr. Timothy Bost.
6. Mr. James Lauder, F.R.S.L., Glasgow Athenæum. Recommended by Major Cassells, Mr. James Provan, and Dr. Henry Dyer.
7. Mr. Henry B. Fyfe, Writer, 115 St. Vincent Street. Recommended by Mr. J. Guthrie Smith, Mr. William Clark, and Mr. D. Johnstone Smith.
8. Mr. Thomas N. Whitelaw, Soap Manufacturer, 87 Sydney Street. Recommended by Mr. William Ewing, Mr. Walter W. Blackie, and Mr. John Garroway.
9. Mr. James Dobson, County Sanitary Inspector, Springfield Avenue, Uddingston. Recommended by Mr. W. P. Buchan, Mr. John Robertson, and Mr. John Mann.
10. Mr. John James Burnet, A.R.I.B.A., 18 University Avenue. Recommended by Dr. M'Kendrick, Dr. J. B. Russell, and Mr. John Mann, jun.
11. Robert Fullerton, M.D., 24 Newton Place. Recommended by Dr. James Colville, Mr. John Mann, jun., and Mr. John Mayer.
12. Mr. Thos. R. Milligan. 22 Arlington Street. Recommended by Dr. James Colville, Mr. John Mann, jun., and Mr John Mayer.

5. Subsequently, the Members adjourned to Dr. M'Kendrick's Laboratories, where there were on view numerous scientific instruments, microscopes, &c.

16th November, 1892.

The Annual General Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 16th November, 1892, at Eight o'clock—Dr. J. G. M'Kendrick, F.R.S., President, in the Chair.

1. The Minutes of the First Ordinary General Meeting for Session 1891-92, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen elected on 2nd November were admitted to the Membership of the Society:—Mr. J. G. A. Baird, M.P., Wellwood, Muirkirk; Dr. James Smith, H.M. Inspector of Schools, St. Peter's Lodge, Uddingston; Mr. William Martin, Shipbroker and Secretary, 116 St. Vincent Street; Mr. Horatio Bell, Assistant Engineer, National Telephone Company, Royal Exchange; Mr. James Murrie, Engineer, 12 Houldsworth Street; Mr. James Lauder, F.R.S.L., Glasgow

Athenæum; Mr. Henry B. Fyfe, Writer, 115 St. Vincent Street; Mr. Thomas N. Whitelaw, Soap Manufacturer, 87 Sydney Street; Mr. James Dobson, County Sanitary Inspector, Springfield Avenue, Uddingston; Mr. John James Burnet, A.R.I.B.A., 18 University Avenue; Robert Fullerton, M.D., 24 Newton Place; and Mr. Thos. R. Milligan, 22 Arlington Street.

3. The Annual Report by the Council on the State of the Society, having been printed in the Billet convening the Meeting, was held as read. Its adoption was moved from the Chair, and unanimously agreed to. The Report is subjoined:—

Report of Council for Session 1891-92.

I. *Meetings.*—During Session 1891-92, which commenced on 4th November, 1891, and closed on 27th April, 1892, there were held thirteen meetings of the Society—all in the Society's Rooms. Twenty-three communications were made to the Society at those meetings. One of them, by arrangement with the Council of the Architectural Section, was a paper by Professor G. Baldwin Brown, M.A., of the Watson-Gordon Chair of Fine Art in the University of Edinburgh. His subject was "Beauty and Utility in Architecture." That paper, and several others, were fully illustrated by Lantern views projected on the screen, which is now a permanent feature in the equipment of the Large Hall. Another paper, which may be specially referred to, was Mr. Fawsitt's "Memoir of the late Professor Dittmar," a distinguished member of the Society. A year ago, when the Council submitted their last Report to the Society, they gave prominence to the fact that it had been agreed to award the Graham Medal to Professor Dittmar, on account of the masterly paper on "The Gravimetric Composition of Water," which he had communicated to the Society on behalf of himself and Mr. J. B. Henderson, one of his laboratory assistants. The medal was presented to him just a year ago, and little did the Council then anticipate that they were so soon to lose by death their esteemed fellow-member and former fellow-councillor.

II. *Membership.*—At the beginning of the Session there were 642 Ordinary Members on the Roll. In the course of the Session 17 candidates were elected to the Membership, and from the "Suspense List" 2 Members were reinstated, making 661. Of these, 16 have resigned, 11 have died, 4 have left Glasgow, and their names have been placed on the "Suspense List," and 2 have been struck off the Roll for non-payment of subscriptions, so that at the beginning of Session 1892-93, there were 628 Members, being a decrease of 14. Of the New Members admitted during the Session, 1 qualified himself as a Life Member. There are now 119 Members of that class. In the List of Honorary Members, the number of whom is limited to 20, there are 3 vacancies existing, so that the Roll now includes 17 Honorary Members, 5 being Continental, 11 American or Colonial, and 8 British. The number of Corresponding Members remains at 10, as it was

a year ago. The Membership of the Society, then, is as follows:—Honorary Members, 17; Corresponding Members, 10; Ordinary Members (Annual and Life), 628; or a total of 655. The fact that only 17 new members were proposed during last Session seems to justify the Council in expressing the hope that the members of the Society generally will do their best to bring forward from time to time, and as early in the Session as possible, new candidates for election, so as to increase the membership. One of the Honorary Members of the Society, Sir A. C. Ramsay, F.R.S., a former Director-General of the Geological Survey of Great Britain and Ireland, died in the course of the past year; and in the month of March of this year, Dr. Thomas Muir, long a valuable member of the Society, was, on the unanimous recommendation of the Council, elected an Honorary Member, on the occasion of his departure from Glasgow to become Superintendent-General of Education in Cape Colony. The Council sincerely regret the death of Dr. Robert Grant, F.R.S., Regius Professor of Astronomy in the University of Glasgow, who was a Member of the Society during the long period of thirty-two years. He served long in the Council, and was for a triennial term President of the Society, and latterly he was one of the Honorary Vice-Presidents.

III. *Sections.*—(1) The *Architectural Section* held seven meetings during the Session. In addition to the President's Opening Address, six papers were read at the meetings, four of which were passed by the Council for publication in the *Proceedings.*

(2) In connection with the *Sanitary and Social Economy Section,* two papers were read before meetings of the Society. The Council authorised their publication.

(3) Through the *Geographical Section* five lectures were delivered during the Session at joint-meetings of the Philosophical Society and the Glasgow Branch of the Royal Scottish Geographical Society.

(4) The *Economic Science Section* brought forward four papers during the Session, three of which were read at meetings of the Society. One of them is published in the *Proceedings.*

(5) Several papers in connection with the *Mathematical and Physical Section* came before the Society in the course of the Session, and one of them appears in the *Proceedings.*

(6) Two papers were communicated to meetings of the Society during the Session from the *Philological Section,* and are published in the *Proceedings.*

IV. *Proceedings*, Vol. XXIII.—The new volume of the Society's *Proceedings* contains the President's Opening Address and seventeen other papers, which are illustrated by plates and numerous figures through the text. The Council believe that this instalment of the Society's work will be much appreciated by the members generally, and by other scientific workers, both at home and abroad.

V. *Index.*—An Index to the first twenty volumes of the *Proceedings* (1841-89), has been prepared and printed, and will be circulated along with

the new volume of the *Proceedings.* The Society is much indebted to Mr. John Robertson for accomplishing this important work, on which he has, for the last three years, bestowed great labour and much of his spare time. A copy of this Index will be supplied to each Member of the Society.

VI. *Finance.*—The Treasurer's Statement opens with a balance of £257 5s. 1d., and closes with a balance of £250 7s. 7½d., being a decrease of Funds during the year of £6 17s. 5½d. It is believed that all current indebtedness of the Society, up to 31st October, 1892, has been paid.

By order and on behalf of the Council.

JOHN MAYER,
Secretary.

4. The Treasurer's audited Statement of the Funds of the Society, which had also been printed in the Billet, was next submitted by the Chairman, and its adoption was unanimously approved of. The Abstract of Treasurer's Account of the Graham Medal and Lecture Fund, and that of the Science Lectures Association Fund, were also submitted and approved of. These Statements, signed by the Auditors, were laid on the table, as also the Inventory of the Society's Property at close of Session, in compliance with the Articles of Association. The several Financial Statements are given on pp. 228-231.

5. Mr. John Robertson, on behalf of the Library Committee, submitted the Report on the State of the Library. Its adoption was agreed to, and, on the motion of Mr. Robertson, the thanks of the Society were awarded to the donors of Books to the Library during the year. The Report was as follows:—

Report of the Library Committee.

The Committee have to report a large increase in the number of readers during the past Session, 652 volumes having been issued to 410 members. The Society receives 100 periodicals, of which 73 are bought. These form altogether 131 volumes.

The presentations made to the Library during the year amounted to 41 volumes, 8 parts of works, and 8 pamphlets; while 80 volumes and 173 parts of works were received in exchange from 170 Societies and Public Departments. The Society purchased 63 volumes, and 20 parts of works. Altogether, there has been an addition to the Library of 184 volumes, 201 parts of works, and 8 pamphlets; making a total of 11,290 volumes.

In Volume XXIII. of the *Proceedings*, pp. 336-349 there will be found a list of the additions to the Library by purchase up to June, 1892, the titles

Dr. ABSTRACT OF HONORARY TREASURER'S
AND COMPARISON WITH

		1891-92.	*1890-91.*
To BALANCE in Bank and Treasurer's hands from last year,		£257 5 1	*£190 1 8*
,, SUBSCRIPTIONS to 31st October, 1892—			
2 Entry-moneys of 1890-91 at 21s., £2 2 0			
17 ,, 1891-92 ,, 17 17 0	£19 19 0		*40 19 0*
Annual Dues at 21s.—			
Arrears, ... £3 3 0			
For 1891-92, 480 Ordinary Members, ... 504 0 0			
,, ,, 18 New Members, 18 18 0	526 1 0		*554 8 0*
Life Subscriptions at £10 10s.—			
5 Old Members, ... £52 10 0			
1 New Member, ... 10 10 0	63 0 0		*52 10 0*
		609 0 0	
,, GENERAL RECEIPTS—			
Bank Interest, ...	£5 6 8		*5 3 10*
Proceedings sold, ...	5 2 4		*0 8 0*
		10 9 0	
,, ARCHITECTURAL SECTION—			
74 Associates' fees for 1891-92, at 5s., ...		18 10 0	*20 15 0*
,, ECONOMIC SCIENCE SECTION—			
25 Associates' fees for 1891-92, at 5s., . .		6 5 0	*7 15 0*
,, GEOGRAPHICAL AND ETHNOLOGICAL SECTION—			
Associates' fees, ...		0 0 0	*8 5 0*
,, MATHEMATICAL AND PHYSICAL SECTION—			
Associate's fee, ...		0 0 0	*0 0 0*
,, PHILOLOGICAL SECTION—			
Associates' fees, ...		0 15 0	*0 0 0*
		£902 4 1	*£880 5 6*

Memo. by Treasurer.—The Amount invested by the Society in the Bath Street Joint Buildings up to 31st October, 1892, is, as in last Account, . £3,547 8 1½
whereof, Paid from Society's Funds, ... £2,047 8 1½
Do. Society's half of £3,000 Bond, . 1,500 0 0
£3,547 8 1½

J. M.

ACCOUNT—SESSION 1891-92, **Cr.**

SESSION 1890-91.

		1891-92.	*1890-91.*
By GENERAL EXPENDITURE to 31st October, 1892—			
Salary to Secretary,	£75 0 0		*£75 0 0*
Allowance for Treasurer's Clerks,	15 0 0		*15 0 0*
		£90 0 0	
New Books & Periodicals, British & Foreign,	£124 15 3½		*111 4 7*
Bookbinding,	0 17 3		*40 0 5*
Printing Circulars, *Proceedings*, &c.,	174 6 9		*155 0 0*
Printing General Index to Vols. I. to XX. of "*Proceedings*,"	28 16 6		
Lithographs, Woodcuts, &c., for *Proceedings*, &c.,	13 14 6		*8 13 3*
Postage and delivery of Circulars, Letters, &c.,	31 14 3		*36 3 11*
Stationery, &c.,	1 17 3		*7 11 7*
		376 1 9½	
Fire Insurance on Library for £5,400,	£6 1 3		*6 1 3*
Postages, &c., per Secretary, £2 9s. 6d.; per Treasurer, £2 3s. 9½d.,	4 13 3½		*5 4 5½*
		10 14 6½	
,, Joint Expenses of Rooms—Society's half of £352 12s. 1d., being Interest on Bond, Insurance, Taxes, Cleaning, Repairs, Lighting, and Heating; Salaries of Curator and Assistant, less half of £68 15s. 0d., Revenue from Letting,		141 18 6½	*128 6 4½*
,, LECTURE EXPENSES—			
Scottish Geographical Society, Rent for five Joint Lectures,	£6 5 0		
Advertising, Reporting, and Sundries,	7 2 6		
		13 7 6	*9 3 3*
,, SUBSCRIPTIONS TO SOCIETIES—			
Ray Society, 1891,	£1 1 0		
Palæontographical Society, 1891,	1 1 0		
		2 2 0	*2 2 0*
,, ARCHITECTURAL SECTION— Expenses per Treasurer of Section,		8 19 4	*9 8 10½*
,, ECONOMIC SCIENCE SECTION—			
Expenses per Treasurer of Section,	£4 7 0		
Printing Account,	2 0 0		
		6 7 0	*10 5 2½*
,, GEOGRAPHICAL AND ETHNOLOGICAL SECTION—			
Expenses per Treasurer of Section,	£0 0 0		
Printing Account,	2 3 3		
		2 3 3	*3 10 3*
,, MATHEMATICAL AND PHYSICAL SECTION— Expenses per Treasurer of Section,		0 0 0	*0 0 0*
,, PHILOLOGICAL SECTION— Expenses per Treasurer of Section,		0 0 0	*0 0 0*
,, SANITARY AND SOCIAL ECONOMY SECTION— Expenses per Treasurer of Section,		0 2 6	*0 5 0*
,, BALANCES, viz. :—			
In Clydesdale Bank,	£355 10 6		
Less due to Treasurer,	105 2 10½		
		250 7 7½	*257 5 1*
		£902 4 1	*£880 5 6*

GLASGOW, *9th November, 1892.*—We, the Auditors appointed by the Society to examine the Treasurer's Accounts for the year 1891-92, have examined the same, of which the above is an Abstract, and have found them correct, the Balances being—in Clydesdale Bank Three Hundred and Fifty-five Pounds Ten Shillings and Sixpence, and due to Treasurer One hundred and five Pounds Two Shillings and Tenpence-halfpenny.

(Signed) DUGALD BELL.

JNO. MANN, C.A., *Honorary Treasurer.* P. MACGREGOR CHALMERS.

GRAHAM MEDAL AND LECTURE FUND.

Dr. ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1891-92. Cr.

CAPITAL AT 1ST NOVEMBER, 1891—		
Glasgow and South-Western Railway Co. 4 % Preference Stock in name of the Philosophical Society, in Trust,	£250 0 0	
Value of Die at H.M. Mint,	18 18 0	
		£268 18 0
Cash in Bank,		29 0 9
REVENUE—		
Dividend, April, 1892, less Tax,	£4 17 6	
,, Oct. ,, ,,	4 17 6	
Interest from Bank,	0 9 8	
		10 4 8
		£308 3 5

EXPENDITURE—		
Gold Medal awarded in November, 1891, to W. Dittmar, LL.D., F.R.S., F.R.S.E., Professor of Chemistry, Anderson's College; for Research on "The Gravimetric Composition of Water," also Silver Medal and Books to Mr. John B. Henderson, for assisting in same,		£13 4 0
CAPITAL AT 31ST OCT., 1892—		
Investment, *per contra*,	£250 0 0	
Die,	18 18 0	
		£268 18 0
BALANCE, BEING REVENUE—		
In Bank, on Deposit Receipt,		26 1 5
		£308 3 5

GLASGOW, 9th November, 1892.—Examined and found correct.

(Signed) DUGALD BELL.
P. MACGREGOR CHALMERS.

JNO. MANN, C.A., *Treasurer*.

THE SCIENCE LECTURES ASSOCIATION FUND.

ABSTRACT OF TREASURER'S ACCOUNT—SESSION 1891-92.

Dr.

CAPITAL AT 1ST NOVEMBER, 1891—						
£200 Caledonian Railway Company 4% Preference Stock, No. 1, in name of the Philosophical Society, in Trust, cost	£244	4	8			
On Deposit Receipt,	8	5	4			
				£252	10	0
Cash in Bank (Revenue),				16	6	5
REVENUE—						
Dividend, April, 1892, less Tax,	£3	18	0			
,, Oct., ,, ,,	3	18	0			
Interest from Bank,	0	7	9			
				8	3	9
				£277	0	2

Cr.

CAPITAL AT 31ST OCTOBER, 1892—						
Investment, *per contra*,	£244	4	8			
In Bank on Deposit Receipt,	8	5	4			
				252	10	0
BALANCE, BEING REVENUE—						
In Bank, on Deposit Receipt,				24	10	2
				£277	0	2

GLASGOW, 9th November, 1892.—Examined and found correct.

(Signed) DUGALD BELL.
P. MACGREGOR CHALMERS.

JNO. MANN, C.A., *Treasurer.*

of the books presented, with the names of the donors, the names of the Societies and Public Departments with which exchanges are effected, and a list of the periodicals received at the Library.

JOHN ROBERTSON, LIBRARIAN,
Convener.

6. On the motion of the Chairman, the best thanks of the Society were awarded to the Treasurer and the Librarian for their services during the past year.

7. The Society then proceeded to the election of Office-Bearers:—

(1) The Chairman stated that his term of office as President had come to a close, and that the Council had unanimously recommended Dr. John Ferguson, M.A., Professor of Chemistry in the University of Glasgow, as his successor. He formally proposed Professor Ferguson, whose election was unanimously agreed to. That gentleman thereupon took the chair, and thanked the members for putting him into such a highly distinguished position, promising that he would do all in his power for the Society and to maintain the character of the Chair.

(2) On the recommendation of the Council, and on the motion of Dr. J. T. Bottomley, F.R.S., Mr. William Lang, jun., F.C.S., was elected to succeed him as a Vice-President.

(3) On the motion of the Chairman, Messrs. Mann, Robertson, and Mayer were re-elected Treasurer, Librarian, and Secretary, respectively.

(4) The following gentlemen were elected members of Council:— Mr. William Jolly, F.R.S.E., Dr. George G. Henderson, M.A., Mr. David Thomson, Mr. Gilbert Thomson, M.A., C.E., and Mr. F. T. Barrett, in succession to Mr. Lang, Dr. Colville, Mr. A. Mechan, and Rev. A. Brunton, whose term of office had expired, and in room of Mr. Kemp, now deceased.

(5) On the motion of Dr. Turner, the Office-Bearers of the Geographical and Ethnological Section were elected, in accordance with Resolution of Society of 11th April, 1883. There were also elected the Office-Bearers of the Sanitary and Social Economy Section, on the motion of Mr. W. P. Buchan; Mathematical and Physical Section, on the motion of Mr. Magnus Maclean; and of the Economic Science Section, on the motion of Mr. W. W. Blackie—according to Resolution of Society of 18th November, 1885, and 2nd February, 1887; and, on the motion of Dr. Colville, the List of Office-Bearers of the Philological Section was agreed to.

8. Mr. John Mann, jun., C.A., read a paper (a Communication from the Economic Science Section) on "Reformed Public-Houses: Notes upon the Scandinavian Licensing systems and the

Bishop of Chester's recent proposals." A discussion followed, in which the speakers were Mr. T. S. Cree, Bailie Chisholm, Mr. D. M. Nelson, and Dr. James Smith. At the close, the Chairman moved a vote of thanks to Mr. Mann, who briefly replied to the various speakers.

9. The Chairman announced that the following candidates had all been elected Members of the Society:—

1. Mr. ARCHIBALD STEWART, Mason and Contractor, 20 Balmoral Terrace, Crosshill. Recommended by Mr. James Frame, Mr. W. P. Buchan, and Mr. Mayer.
2. Dr. A. R. CHALMERS, 4 Rosebery Terrace, Kelvinbridge. Recommended by Dr. J. B. Russell, Dr. Neil Carmichael, and Mr. W. R. M. Church.
3. Dr. THOMAS WILSON JENKINS, M.A., Physician to Glasgow Samaritan Hospital. Recommended by Dr. Eben. Duncan, Dr. J. B. Russell, and Mr. John Robertson.

30th November, 1892.

The Second Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 30th November, 1892, at Eight o'clock—Professor Ferguson, LL.D., President, in the Chair.

1. The Minutes of the Annual General Meeting, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 16th November, were admitted to the Membership of the Society:—Mr. Archibald Stewart, Mason and Contractor, 20 Balmoral Terrace, Crosshill; Dr. A. L. Chalmers, Medical Officer of Health, 4 Rosebery Terrace, Kelvinbridge; Dr. Thomas Wilson Jenkins, M.A., Physician to Glasgow Samaritan Hospital.

3. The President asked the Society to join him in passing a very hearty vote of thanks to Dr. M'Kendrick, his predecessor in the chair, whose services to the Society as President, as Secretary, and as author of valuable papers, were worthy of all praise. The motion was passed with applause.

4. Mr. Magnus Maclean, M.A., F.R.S.E., read a paper on "Some Recent Experiments with a Ruhmkorff Coil," which called forth some remarks from Professor Blyth, Professor Jamieson, Mr. H. A. Mavor, and Dr. J. T. Bottomley; and, on the motion of the last-named gentleman, Mr. Maclean was awarded a hearty vote of thanks.

5. Mr. Andrew W. Meikle, M.A., made a communication to the Society on "The 'Kelvin' Electricity Meter." A discussion took place, in which the speakers were Mr. Townsend, Mr. Sayers, Professor Blyth, Dr. Bottomley, Mr. H. A. Mavor, and Mr. Sam. Mavor. Mr. Meikle briefly replied, and was cordially thanked for his paper.

6. The Chairman announced that the following candidates had all been elected Members of the Society :—

1. Councillor James M. Thomson, Engineer, Glen-Tower, Kelvinside. Recommended by Lord Provost Bell, Deacon-Convener Copland, and Mr. W. Foulis.
2. Mr. John Ferguson Campbell, Manure Manufacturer, 2 Lugar Place. Recommended by Mr. John Mann, Mr. John Mann, jun., and Mr. John Robertson.
3. Mr. George B. Caldwell, Brooklyn, Dennistoun. Recommended by Mr. James T. Tullis, Mr. David Thomson, and Mr. Adam Ker.
4. Mr. Maxwell Hedderwick, 3 Woodside Place. Recommended by Mr. T. L. Watson, Mr. Charles S. Moir, and Mr. W. Forrest Salmon.
5. Mr. James Rankin Brownlie, Dentist, 220 West George Street. Recommended by Mr. John Honeyman, Mr. James Muir, and Mr. David Thomson.
6. Mr. John Scott, Painter and Decorator, 245 Sauchiehall Street. Recommended by Mr. John Honeyman, Mr. James Muir, and Mr. David Thomson.
7. Mr. A. C. Whyte, L.D.S., 42 Dundas Street. Recommended by Mr. John Honeyman, Mr. James Muir, and Mr. David Thomson.
8. Mr. James Crichton, Wholesale Tea Dealer, 47 Nithsdale Drive, Pollokshields. Recommended by Mr. Charles A. Fawsitt, Mr. William Lang, jun., and Mr. John Robertson.
9. Mr. Patrick James Pringle, Manufacturer, 115 Mains Street, Blythswood Square. Recommended by Dr. J. T. Bottomley, Mr. Magnus Maclean, and Mr. Andrew W. Meikle.
10. Mr. Henry W. Christie, Chemist, Levenfield House, Alexandria. Recommended by Mr. John Christie, Mr. Robert R. Tatlock, and Mr. John Mayer.
11. Mr. Alexander Hay, County Sanitary Inspector, 56 George Square. Recommended by Dr. J. B. Russell, Mr. James Parnie, and Mr. James R. Motion.

14th December, 1892.

The Third Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the evening of Wednesday, 14th December, 1892, at Eight o'clock—Professor Ferguson, President, in the Chair.

1. The Minutes of the General Meeting of 30th November, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 30th November, were admitted to the Membership of the Society:—Councillor James M. Thomson, Engineer, Glen-Tower, Kelvinside; Mr. John Ferguson Campbell, Manure Manufacturer, 2 Lugar Place; Mr. George B. Caldwell, Brooklyn, Dennistoun; Mr. Maxwell Hedderwick, 3 Woodside Place; Mr. James Rankin Brownlie, Dentist, 220 West George Street; Mr. John Scott, Painter and Decorator, 245 Sauchiehall Street; Mr. A. C. Whyte, L.D.S., 42 Dundas Street; Mr. James Crichton, Wholesale Tea Dealer, 47 Nithsdale Drive, Pollokshields; Mr. Patrick James Pringle, Manufacturer, 115 Mains Street, Blythswood Square; Mr. Henry W. Christie, Chemist, Levenfield House, Alexandria; Mr. Alexander Hay, County Sanitary Inspector, 56 George Square.

3. Mr. Robert M. W. Swan, member of the Archæological Exploration Party of Central Africa, read a paper on "The Geography and Ethnology of Mashonaland, with a Brief Account of the Ruins of Zimbabwe" (a communication from the Geographical and Ethnological Section), which was extensively illustrated by lantern views. At the close of the paper Mr. Swan was awarded the best thanks of the Society.

4. The Chairman announced that the following Candidates had been unanimously elected Members of the Society:—

1. Mr. J. M'Kellar, Property Agent, 25 Kelvinside Avenue. Recommended by Mr. John Mann, Bailie Parnie, and Mr. Mayer.
2. Mr. James Whyte, Merchant, 62 Robertson Street. Recommended by Mr. John Mann, Mr. T. B. Fotheringham, and Mr. Mayer.
3. Mr. John Munro, Student, 69 Bank Street, Hillhead. Recommended by Dr. J. G. M'Kendrick, Dr. Freeland Fergus, and Professor Blyth.
4. Mr. John Y. King, Writer, 142 St. Vincent Street. Recommended by Mr. T. B. Fotheringham, Mr. John Mann, jun., and Mr. Mayer.

5. Mr. Thomas Scott, Electrical Engineer, 2 Teviot Terrace, Kelvinside. Recommended by Mr. Gilbert Thomson, Mr. John Young, jun., and Mr. Mayer.
6. Mr. James Knight, M.A., B.Sc., 121 Kenmure Street, Pollokshields. Recommended by Mr. William Reid, Mr. William Milne, and Dr. George A. Turner.

11th January, 1893.

The Fourth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 11th January 1893, at Eight o'Clock. In the absence of the President and Vice-Presidents, Mr. Mann, Treasurer, occupied the Chair at the opening of the proceedings; subsequently Mr. William Smart, as Vice-President of the Economic Science Section, presided.

1. The Minutes of the General Meeting of 14th December, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 14th December, were admitted to the Membership of the Society:—Mr. J. M'Kellar, Property Agent, 25 Kelvinside Avenue; Mr. James White, Merchant, 62 Robertson Street; Mr. John Munro, Student, 69 Bank Street, Hillhead; Mr. John Y. King, Writer, 142 St. Vincent Street; Mr. Thomas Scott, Electrical Engineer, 2 Teviot Terrace, Kelvinside; Mr. James Knight, M.A., B.Sc., 121 Kenmure Street, Pollokshields.

3. A continuation of the discussion was taken on the subject of "Reformed Public-Houses," which was brought before the Society on 16th November in a paper read by Mr. John Mann, jun., M.A., C.A. The discussion was reopened by Mr. J. Y. King, Writer, in a short paper. The subsequent speakers included a number of Members of the Society and several visitors—namely, Messrs. Robert Mackay, L. Talbot Crosbie, Walter W. Blackie, — Crichton, John Edwards, Arthur Mechan, J. Mann Ross, A. W. Whitson, Donald M'Lean, J. Hamilton, D. M. Stevenson, and John Stevenson. Short replies were made by Messrs. Mann and King.

4. The Chairman announced that the following Candidates had been unanimously elected Members of the Society :—

1. Mr. THOMAS ADAM, Property Agent, 27 Union Street. Recommended by Bailie Parnie, Mr. John Dansken, and Mr. James Barr.
2. Councillor MACLAY, Corn Factor, Corn Exchange Buildings, Glasgow. Recommended by Lord Provost Bell, Mr. David T. Maclay, and Mr. John Mann, jun.
3. Mr. RICHARD BROWNE, Coachbuilder, Beechholm, Queen's Drive, Crosshill. Recommended by Dr. Thomas W. Jenkins, Mr. John Mann, jun., and Mr. William Lang, jun.
4. Mr. ROBERT BROWN, B.Sc. (Glas.), Merchant, 45 Washington Street. Recommended by Professor Ferguson, Mr. William Lang, jun., and Mr. Campbell Douglas.
5. Mr. WALTER DIXON, Electrical Engineer, 7 Bothwell Street. Recommended by Mr. John Mayer, Mr. John Mann, and Mr. H. A. Mavor.

25th January, 1893.

The Fifth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 25th January, 1893, at Eight o'Clock—Professor Ferguson, President, in the Chair.

1. The Minutes of the General Meeting of 11th January, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 11th January, were admitted to the Membership of the Society :—Mr. Thomas Adam, Property Agent, 27 Union Street; Councillor Maclay, Corn Factor, Corn Exchange Buildings, Glasgow; Mr. Richard Browne, Coachbuilder, Beechholm, Queen's Drive, Crosshill; Mr. Robert Brown, B.Sc. (Glas.), Merchant, 45 Washington Street; Mr. Walter Dixon, Electrical Engineer, 7 Bothwell Street.

3. Mr. Robert Thomas Moore, B.Sc., Civil and Mining Engineer, read a paper on "The Recent Developments of the Hamilton Coal-Field," which was illustrated by Maps and Sections. The paper gave prominence to the recent, present, and prospective output of coal from the deposits in Mid-Lanarkshire and other parts of the county. A discussion took place, in which the speakers were Mr. H. A. Mavor, Mr. George C. Thomson, Mr. W. P. Buchan, and Mr. Ralph Moore, ex-Inspector of Mines. The

author was accorded a hearty vote of thanks, which he acknowledged, and briefly replied on the discussion.

4. Mr. W. P. Buchan, Sanitary Engineer, briefly described methods of ventilating rooms by means of the windows, &c. Mr. Gilbert Thomson, M.A., C.E., made some remarks on the subject of the communication, for which Mr. Buchan received the thanks of the Society.

5. The Chairman announced that the following Candidates had been unanimously elected Members of the Society:—

1. Mr. Wm. P. Ure, Regent Mills, Sandyford. Recommended by Mr. Henry Mavor, Mr. W. Arthur Coulson, and Mr. Sam. Mavor.
2. Mr. A. W. Whitson, jun., Ardlui, Bearsden. Recommended by Mr. John Y. King, Mr. John Mann, jun., and Mr. Walter W. Blackie.
3. Mr. F. N. Sloane, C.A., 187 West George Street. Recommended by Mr. John Mann, jun., Mr. William Smart, and Mr. Walter W. Blackie.
4. Mr. William Ross, Brassfounder, 44 South Portland Street. Recommended by Mr. W. P. Buchan, Mr. Wm. Anderson, and Mr. Wm. A. Rattray.
5. Professor J. H. Biles, "Elder" Chair of Naval Architecture. Recommended by Professor J. G. M'Kendrick, Professor John Ferguson, and Professor A. Barr.

8th February, 1893.

The Sixth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 8th February, 1893, at Eight o'Clock—Mr. William Lang, jun., F.C.S., Vice-President in the Chair.

1. The Minutes of the General Meeting of 25th January, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. The following gentlemen, elected on 25th January, were admitted to the Membership of the Society:—Mr. Wm. P. Ure, Regent Mills, Sandyford; Mr. A. W. Whitson, jun., Ardlui, Bearsden; Mr. F. N. Sloane, C.A., 187 West George Street; Mr. William Ross, Brassfounder, 44 South Portland Street; Professor J. H. Biles, "Elder" Chair of Naval Architecture.

3. Two papers on "The Education of the Deaf and (so-called) Dumb" were read by Dr. James Kerr Love, Aural Surgeon to the Glasgow Royal Infirmary and Aurist to the Glasgow Institution for the Education of the Deaf and Dumb, and Mr. W. H. Addison, Associate of the College of Preceptors, Head Master of the Institution. They were illustrated by children under tuition at the Langside Institution. A discussion followed, in which the speakers were Dr. Eben. Duncan, Dr. Thomas Barr, Mr. P. Falconer, Mr. William Bottomley, Dr. James Erskine, and Mr. W. J. Wood; and the authors were cordially thanked for their very interesting communications.

22nd February, 1893.

The Seventh Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 22nd February, 1893, at Eight o'Clock—Professor John Ferguson, LL.D., President, in the Chair.

1. The Minutes of the General Meeting of 8th February, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. A paper was read by Sheriff Mark Davidson on "The Elements of Profits," being a communication from the Economic Science Section. A discussion followed, in which the speakers were Messrs. T. S. Cree, Younger, Barclay, Sloane, and W. W. Blackie. The author briefly replied, and was awarded a hearty vote of thanks for his paper.

8th March, 1893.

The Eighth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 8th March, 1893, at Eight o'Clock—Professor John Ferguson, LL.D., President, in the Chair.

1. The Minutes of the General Meeting of 22nd February, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. A Lecture was delivered by Mr. F. C. Selous, African Traveller and Hunter, on "Twenty Years of Travel in Central South Africa," for which he was awarded the thanks of a very large Meeting of Members and friends. (This was a communication from the Geographical and Ethnological Section.)

3. The following Candidate was elected a Member of the Society:—

Mr. STUART BELL, Electrical Engineer, 264 St. Vincent Street. Recommended by Dr. J. G. M'Kendrick, Mr. John Mann, and Mr. John Mayer.

22nd March, 1893.

The Ninth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 22nd March, 1893, at Eight o'Clock—Professor James Blyth, M.A., F.R.S.E., Vice-President, in the Chair.

1. Mr. Stuart Bell, Electrical Engineer, 264 St. Vincent Street, was admitted to the Membership of the Society.

2. The Minutes of the General Meeting of 8th March, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

3. Dr. Freeland Fergus, Surgeon to the Glasgow Eye Infirmary, read a paper on "The Light Sense in relation to Navigation." A discussion followed, in which the speakers were—Professor Jamieson, Professor Blyth, Mr. M'Whirter, and Dr. Snodgrass. On the motion of the Chairman, the thanks of the Society were awarded to Dr. Fergus.

4. Professor Jamieson, M. Inst. C. E., F. R. S. E., &c., read a paper on "Comparative Tests of 'Hellesen' and 'E.C.C.' Dry Battery Cells," on which some remarks were made by Mr. M'Whirter and Professor Blyth. The author was cordially thanked for his paper.

5th April, 1893.

The Tenth Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 5th April, 1893, at Eight o'Clock—Professor Ferguson, LL.D., President, in the Chair.

1. The Minutes of the General Meeting of 22nd March, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Professor William Jack, LL.D., read a "Memoir of the late Dr. Robert Grant, F.R.S., Professor of Astronomy in the University of Glasgow, and a former President of the Philosophical Society," for which he was awarded the thanks of the Society.

3. A paper on "Exploration of the Amazonian Provinces of Central Peru," by Mr. Alexander Ross, F.R.G.S., London and Ceylon, was read by the Secretary, in the absence of the author. The paper was fully illustrated by Lime-Light Views. On the motion of the President, the thanks of the Society were awarded to the author of the paper and to the Secretary.

19th April, 1893.

The Eleventh Ordinary Meeting of the Philosophical Society of Glasgow was held in the Society's Rooms, 207 Bath Street, on the Evening of Wednesday, 19th April, 1893, at Eight o'Clock—Mr. William Lang, jun., F.C.S., Vice-President, in the Chair.

1. The Minutes of the General Meeting of 5th April, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Mr. W. F. Murray, Caledonian Pottery, Rutherglen, read a paper on "A New System of using Gaseous Fuel in Firing Pottery-Ware." A discussion ensued, in which the speakers were—Mr. Robert Cochrane, Verreville Pottery; Mr. James Crichton, Dr. Eben. Duncan, — Wallace, and the Secretary. A cordial vote of thanks was passed to Mr. Murray for his paper.

3. An interesting paper, entitled "A Mining Engineer's Notes of a Recent Visit to South Africa," was read by Mr. A. G. Moore, M.A., C.E. & M.E., for which he received the best thanks of the Society.

4. Mr. William Aitken, Assoc.Inst.E.E., Engineer to the National Telephone Company, read a short paper on "Special Applications of the Telephone," which was practically illustrated. The author was heartily thanked for his communication and demonstration.

3rd May, 1893.

The Twelfth and concluding Ordinary Meeting of the Philosophical Society of Glasgow, for Session 1892-93, was held in the Society's Rooms, 207 Bath Street, on the Evening of 3rd May, 1893, at Eight o'Clock—Professor Ferguson, LL.D., President, in the Chair.

1. The Minutes of the General Meeting of 19th April, 1893, which were printed in the Billet calling the Meeting, were held as read, were approved of, and signed by the Chairman.

2. Dr. J. T. Bottomley, F.R.S., made three communications to the Society—(*a*) "On Vacuum Tubes without Electrodes;" (*b*) "On Some Results of Instantaneous Photography;" (*c*) "On a Portable Instrument for Testing the Insulation of Electric Light Wires." They were illustrated by apparatus, experiments, and lantern demonstrations. After a few remarks by Members, Dr. Bottomley was awarded the best thanks of the Society.

3. The Annual Reports by Secretaries of Sections were submitted by the Secretary of the Society, who stated that a paper by Mr. W. Anderson Smith, Member of the Scottish Fishery Board, on "Improved Appliances for Marine Investigation," would be read next Session.

4. The President then dismissed the Society for the Summer Recess.

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SESSION 1892-93.

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Appendix to the Fifty-eighth Report of the Commissioners of National Education in Ireland for 1891. 8vo. Dublin, 1892, . .	Mr. Alex. Cross, M.P.
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Agricultural Statistics of Ireland for 1891. Folio. Dublin, 1892, ...	,,
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Reports of the Chief Registrar of Friendly Societies for 1891. 8vo. London, 1892, .	,,
Report of the Kelvingrove Museum and Corporation Art Galleries of Glasgow for 1891, . .	Mr. James Paton.
Wattles and Wattlebarks, being Hints on the Cultivation of Wattles. 2nd Edition. By J. H. Maiden. 8vo. Sydney, 1891, . .	The Technological Museum, Sydney.
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A Bibliography of Australian Economic Botany. Part 1. By J. H. Maiden. 8vo. Sydney, 1892, ...	,,
Grant, Robert. Second Glasgow Catalogue of 2,156 Stars for the Epoch 1890. 4to. Glasgow, 1892, ...	The Author.
Annandale, C. Scotland in Prehistoric Times,	Messrs. Blackie & Son.
Parkin, G. R. Imperial Federation, with Map. 8vo. London, 1892, ...	Robert Duncan.
Parkin, G. R. Round the Empire. 8vo. London, 1892, ...	,,
Cuthbert, Alex. A. Questions on the Holy Scriptures, with Answers. 8vo. Glasgow, 1893, ...	The Author.
Pilling, J. C. Bibliography of the Athabascan Languages, ...	Smithsonian Institution
Michelson, A. A. On the Application of Interference Methods of Spectroscopic Measurements, ...	,,
Keiler, Chas. A. Evolution of the Colors of North American Land Birds. 8vo. San Francisco, 1893, ...	California Academy of Sciences.
Croll, James. What determines Molecular Motion? The Fundamental Problem of Nature. 8vo Pamphlet. 1872, . . .	Dr. J. B. Russell.
Everett, J. D. On Mirage. 8vo Pamphlet. 1872, ...	,,
Eastwood, J. W. Darwinism in its relation to the Higher Faculties of Man. 8vo Pamphlet. 1873, ...	,,
Hunt, Robert. Electro-Magnetism as a Motive Power. 8vo Pamphlet. 1858, . . .	,,

NEW BOOKS RECENTLY ADDED TO THE LIBRARY BY PURCHASE.

Karmarsch and Heeren's Techniches Wörterbuch. Band 11.

Wright, Lewis. Light: A Course of Experimental Optics, chiefly with the Lantern. 2nd Edition. 8vo. London, 1892.

Die Entwickelung der Kartographie von Amerika, bis 1570. Von Sophus Ruge (Petermanns Mitteilungen, Supplement No. 106), 1892.

La Nature, 1892.

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Rivington's Building Construction. Vols. 2 and 4. 8vo. London, 1891-92.

Philosophical Transactions of the Royal Society. Vol. 183.

L'Année Scientifique for 1892.

Memoirs of the Literary and Philosophical Society of Manchester. Vols. 1-4. 1781-95. 8vo. Warrington.

Journal of the Royal Agricultural Society of England. General Index. 2nd Series. 1865-89. 8vo. London, 1890.

Geological Society of London. A Classified Index to the Transactions, Proceedings, and Quarterly Journal. 2nd Edition. Including all the Memoirs and Notices to the end of 1889. By George W. Ormerod. 8vo. London, 1870-90.

Astronomical Observations made at the Royal Observatory, Edinburgh. Vols. 1-3, 1834-37; Vol. 11, 1849-50; Vol. 13, 1860-69. 5 vols. bound in 3. 4to. Edinburgh.

Symons, G. J. On the Distribution of Rain over the British Isles. 13 vols. 1860-72. 8vo. London.

Hardwicke's Science Gossip. 8 vols. 1865-72. 8vo. London.

Anthropological Review. Vols. 1 to 5. 1863-67. 8vo. London.

Statesman's Year-Book, 1893.

Reclus, E. Universal Geography. Vol. 16. United States. 4to. London.

Œuvres Complètes de Laplace, Tome Neuvieme. 1893.

Œuvres Complètes D'Augustin Cauchy. 1st Series. Tome 8. 1893.

Die Bevölkerung der Erde. Supplement No. 107. Petermanns Mitteilungen. 1893.

Watt's Dictionary of Chemistry. By Morley and Muir. Vol. 3. 8vo. London, 1893.

Huxley, T. H. Essays upon some Controverted Questions. 8vo. London, 1892.

Arlidge, J. T. Hygiene Diseases and Mortality of Occupations. 8vo. London, 1892.

Hudson, W. H. Idle Days in Patagonia. 8vo. London, 1893.

Foster, M. Text-book of Physiology. 5th Edition. 5 vols. 8vo. London, 1889-91.

Thomson, J. J. Applications of Dynamics to Physics and Chemistry. 8vo. London, 1888.

Brown, J. D. Hand-book of Library Appliances. 8vo. London, 1892.

Bent. J. T. The Ruined Cities of Mashonaland. 8vo. London, 1892.

Ostwald, W. Outlines of General Chemistry. Translated by James Walker. 8vo. London, 1890.

Journal of Iron and Steel Institute. Vols. 1 and 2. 1892.

Selous, F. C. A Hunter's Wanderings in Africa. 3rd Edition. 8vo. London, 1893.

Caird, Edward. The Evolution of Religion. 2 vols. 8vo. Glasgow, 1893.

Marsden, Kate. On Sledge and Horseback to Outcast Siberian Lepers. 8vo. London. No date.

Argyll, Duke of. The Unseen Foundations of Society. 8vo. London, 1893.

Dictionary of National Biography. Vols. 32, 33, and 34.

Zoological Record. Vol. 28, for 1891.

Palæontographical Society's Publications :—

Stromatoporoids. By H. A. Nicholson. Part 4. Plates 26-29.

Jurassic Gasteropoda. By W. H. Hudleston. Part 1, No. 6. Plates 21-26.

Inferior Oolite Ammonites of the British Isles. By S. S. Buckman. Part 7. Plates 57-76.

Palæozoic Phyllopoda. By T. R. Jones and H. Woodward. Part 2. Plates 13-17.

Devonian Fauna of the South of England. By G. F. Whidborne. Vol. II., Part 2. Plates 6-10.

Die Kordillere von Bogotá. By Alfred Hettner. (Supplement No. 104, Petermanns Mitteilungen, 1892.)

Durchquerung von Grönland, 1888. By H. Mohn and F. Nansen. (Supplement No. 105, Petermanns Mitteilungen, 1892.)

Wright, G. F. Man and the Glacial Period, with an Appendix on Tertiary Man. By H. W. Haynes. 8vo. London, 1892.

Hunt, Edmund. Colour Vision. Sm. 4to. Glasgow, 1892.

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Hazell's Annual for 1893.

Alison, Robert. Anecdotage of Glasgow. 8vo. Glasgow, 1892.

Brothers, A. Photography: its History, Processes, Apparatus, and Materials. 8vo. London, 1892.

Cunningham, W. The Growth of English Industry and Commerce. 2 vols. 8vo. Cambridge, 1890 and 1892.

Romanes, G. J. Darwin and After Darwin: an Exposition of the Darwinian Theory and a Discussion of Post-Darwinian Questions. 8vo. London, 1892.

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Frost, Percival. An Elementary Treatise on Curve Tracing. 2nd edition. 8vo. London, 1892.

Thomson, Sir William. Mathematical and Physical Papers. Vol. 3. 8vo. London, 1890.

King's Handbook of the United States. 8vo. Buffalo, 1891.

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Dixon, Charles. Migration of Birds. 8vo. London, 1892.

Whymper, E. How to use the Aneroid Barometer. 8vo. London, 1891.

Mackinnon, James. Culture in Early Scotland. 8vo. London, 1892.

Geikie, Sir Archibald. Text-book of Geology. 2nd edition. 8vo. London, 1892.

Lilford, Lord. Coloured Figures of the Birds of the British Islands. Parts 12 to 20.

Palgrave's Dictionary of Political Economy. Parts 4 and 5.

Spencer, H. Principles of Ethics. Vol. 2. 8vo. London, 1893.

Mivart, St. George. Types of Animal Life. 8vo. London, 1893.

Buckler, W. Larvæ of British Butterflies and Moths. Vol. 5. Edited in part by H. T. Stainton. 8vo. London, 1893.

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Jahres-Bericht über die leistungen der Chemischen. Technologie for 1892.

Thorpe, T. E. Dictionary of Applied Chemistry. Vol. 3. 8vo. London, 1893.

Geikie, James. Fragments of Earth Lore. 8vo. Edinburgh, 1893.

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Cameron, Peter. Monograph of the British Phytophagous Hymenoptera. Vol. 4. 8vo. London, 1893.

The Philosophical Society Exchanges with the following Societies, &c. :—

AUSTRALIA.

Brisbane—
- Royal Geographical Society of Australasia (Queensland Branch).

Melbourne—
- Royal Observatory Library.
- Patent Office.
- Royal Society of Victoria.

Sydney—
- Department of Mines.
- Royal Geographical Society of Australasia (New South Wales Branch).
- Royal Society of New South Wales.
- Technological Museum.

BELGIUM.

Brussels—
- Académie Royale des Sciences.
- Observatoire Royale.
- Société Malacologique de Belgique.

Liège—
- Société Royale des Sciences.

CANADA.

Halifax—
- Nova Scotian Institute of Natural Science.

Hamilton (Ont.)—
- Hamilton Association.

London (Ont.)—
- Entomological Society of Ontario.

Montreal—
- Canadian Society of Civil Engineers.
- Geological and Natural History Survey of Canada.
- Royal Society of Canada.

Quebec—
- Literary and Historical Society.

CANADA—*continued.*

Toronto—
Canadian Institute.

Winnipeg—
Manitoba Historical and Scientific Society.

CHILI.

Santiago—
Sociedad Cientifica Alemana.

CHINA.

Hong Kong—
Hong Kong Observatory.

ENGLAND AND WALES.

Barnsley—
Midland Institute of Mining, Civil, and Mechanical Engineers.

Bath—
Bath Natural History and Antiquarian Field Club.

Berwick—
Berwickshire Naturalists' Field Club.

Birkenhead—
Birkenhead Literary and Scientific Society.

Birmingham—
Philosophical Society.

Bristol—
Bristol Naturalists' Society.

Cambridge—
Philosophical Society.
University Library.

Cardiff—
Cardiff Naturalists' Society.

Essex—
Essex Field Club.

Falmouth—
Royal Cornwall Polytechnic Society.

Folkestone—
Folkestone Natural History Society.

Greenwich—
Royal Observatory.

Leeds—
Leeds Philosophical and Literary Society.

Leicester—
Leicester Literary and Philosophical Society.

ENGLAND AND WALES—*continued.*

Liverpool—
- Geological Society.
- Historic Society of Lancashire and Cheshire.
- Literary and Philosophical Society.
- Liverpool Engineering Society.
- Liverpool Naturalists' Field Club.

London—
- Anthropological Institute.
- Architects' Register.
- British Museum.
- British Museum (Nat. His.).

London—
- Chemical Society.
- Institution of Civil Engineers.
- Institution of Mechanical Engineers.
- Junior Engineering Society.
- Middlesex Hospital.
- Patent Office Library.
- Pharmaceutical Society.
- Photographic Society.
- Physical Society of London.
- Royal Geographical Society.
- Royal Institute of British Architects.
- Royal Institution of Great Britain.
- Royal Meteorological Society.
- Royal Society.
- Royal Statistical Society.
- Society of Arts.
- Society of Biblical Archæology.
- Society of Engineers.
- Society of Psychical Research.
- The *Lancet*.

Manchester—
- Manchester Association of Engineers.
- Geographical Society.
- Literary and Philosophical Society of Manchester.
- *Industries*.

Middlesborough—
- Cleveland Institution of Engineers.

Newcastle-upon-Tyne—
- North-East Coast Institution of Engineers and Shipbuilders.
- North of England Institute of Mining and Mechanical Engineers.
- Society of Chemical Industry.

Swansea—
- South Wales Institute of Engineers.

ENGLAND AND WALES—*continued.*

Truro—
Royal Institution of Cornwall.

Watford—
Hertfordshire Natural History Society and Field Club.

Welshpool—
Powys Land Club.

FRANCE.

Bordeaux—
Société des Sciences Physiques et Naturelles.

Paris—
École Polytechnique.
Observatoire Météorologique Central de Montsouris.

GERMANY.

Berlin—
Deutsche Chemische Gesellschaft.
Deutscher Kolonial Verein.
Königlich Preussische Akademie der Wissenschaften.

Bremen—
Geographische Gesellschaft.

Giessen (Hesse)—
Oberhessische Gesellschaft für Natur-und Heilkunde.

Griefswald (Prussia)—
Geographische Gesellschaft.

Halle (Prussia)—
Verein für Erdkunde.
Kaiserliche Leopoldina Carolina Akademie der Deutschen Naturforscher.

Hamburg—
Geographische Gesellschaft.

INDIA.

Calcutta—
Geological Survey of India.

IRELAND.

Belfast—
Belfast Naturalists' Field Club.
Natural History and Philosophical Society.

Dublin—
Royal Dublin Society.
Royal Irish Academy.

ITALY.

Milan—
Reale Instituto di Lombardo.

JAPAN.

Tokio—
Imperial University of Japan (College of Medicine).
Seismological Society of Japan.
University of Tokio.

MEXICO.

Mexico—
Observatorio Meteorológico-Magnetico Central de Mexico.
Observatorio Astronómico Nacional de Tacubaya.
Sociedad Cientifica "Antonio Alzate."

NEW ZEALAND.

Wellington—
Colonial Museum.

NETHERLANDS.

Amsterdam—
Academie Royale des Sciénces.

Harlem—
La Société de Sciences á Harlem.
Teyleryan Library.

Leyden—
Kon. Nederlandisch Aardrijkskundig Genootschap.

NORWAY.

Christiania—
Kongelige Norske Universitet.

PORTUGAL.

Lisbon—
Academia Real das Sciencias.

RUSSIA.

Kazan—
Imperial Kazan University.

St. Petersburg—
Russian Chemical Society of the University of St. Petersburg.

SCOTLAND.

Aberdeen—
Philosophical Society.

Edinburgh—
Advocates' Library.
Geological Society.
Royal Botanic Gardens.
Royal Physical Society.
Royal Scottish Geographical Society.
Scottish Meteorological Society.
Royal Scottish Society of Arts.
Royal Society.

Glasgow—
Archæological Society.
Faculty of Physicians and Surgeons of Glasgow.

Glasgow—
Geological Society.
Glasgow and West of Scotland Technical College Library.
Institution of Engineers and Shipbuilders in Scotland.

SCOTLAND—*continued.*

Glasgow—
Mitchell Library.
Natural History Society of Glasgow.
Stirling's Public Library.

Greenock—
Philosophical Society.

Hamilton—
Mining Institute of Scotland.
Public Library.

Paisley—
Public Library.

SWEDEN.

Stockholm—
Kongliga Svenska Vetenskaps-Akademien.

TASMANIA.

Hobart Town—
Royal Society of Tasmania.

UNITED STATES.

Baltimore—
Johns Hopkins University.

Boston—
American Academy of Arts and Sciences.
Public Library.
Society of Natural History.

Cincinnati—
Ohio Mechanics' Institute.

Davenport (Iowa)—
Academy of Natural Sciences.

Madison—
Washburn Observatory.

Minneapolis—
Geological and Natural History Society of Minnesota.

Newhaven (Conn.)—
Connecticut Academy of Arts and Sciences.

New York—
American Geographical Society.
American Museum of Natural History.
American Society of Civil Engineers.
Astor Library.
New York Academy of Sciences.
School of Mines, Columbia College.

UNITED STATES—*continued.*

Philadelphia—
- Academy of Natural Science of Philadelphia.
- Alumni Association.
- American Pharmaceutical Association.
- American Philosophical Society.
- Franklin Institute.
- Numismatic and Antiquarian Society of Philadelphia.
- Wagner Free Institute of Science.

Rochester (N. Y.)—
- Rochester Academy of Science.

St. Louis—
- Academy of Science.
- Public School Library.

San Francisco (California)—
- California Academy of Sciences.

Scranton (Pa.)—
- Colliery Engineer Publishing Company.

Topeka (Kansas)—
- Kansas Academy of Science.

Trenton (N. J.)—
- Trenton Natural History Society.

Washington—
- Bureau of Education (Department of the Interior).
- Smithsonian Institution.
- United States Naval Observatory.
- United States Geological Survey.

LIST OF PERIODICALS.

(Those received in exchange are indicated by an asterisk.)

WEEKLY.

Academy.
Architect.
Athenæum.
British Architect.
British Journal of Photography.
Builder.
Building News.
Chemical News.
Comptes Rendus.
Dingler's Polytechnisches Journal.
Economist.
Electrical Review.
Electrician.
Engineer.
Engineering.
English Mechanic.
*Industries and Iron.
*Journal of the Society of Arts.
Journal of Gas Lighting, &c.
*Lancet.
Nature.
Notes and Queries.
*Pharmaceutical Journal.
Publishers' Circular.
Science.
Scientific American and Supplement.

FORTNIGHTLY.

Annalen der Chemie (Liebig's).
Berichte der Deutschen Chemischen Gesellschaft.
Journal für Praktische Chemie (Erdmann's).
Zeitschrift für Angewandte Chemie.

MONTHLY.

*American Chemical Journal.
American Journal of Science.
Analyst.
Annalen der Physik und Chemie.
Annales de Chimie et de Physique.
Annales de l'Institut Pasteur.
Annales des Ponts et des Chaussées.
Annales des Sciences Naturelles—Botanique.
Annales des Sciences Naturelles. (Zoologie.)
Annals and Magazine of Natural History.
Antiquary.
Beiblätter zu den Annalen der Physik und Chemie.
*Boletin Mensuel d'Observatorio Meteorologico-Magnetico Central de Mexico.
Bookseller.
Bulletin de la Société d'Encouragement.
Bulletin de la Société Géologique de France.
Bulletin de la Société Industrielle de Mulhouse.
*Bulletin Mensuel de l'Observatoire de Montsouris.
*Canadian Entomologist.
Chamber of Commerce Journal.
*Deutsche Kolonialzeitung.
Economic Journal.
Entomologist.
Entomologists' Monthly Magazine.
Geological Magazine.
Hardwicke's Science Gossip.
*Johns Hopkins University Circulars.
Journal de Pharmacie et de Chimie.
Journal of Botany.
*Journal of the Chemical Society.
*Journal of the Franklin Institute.
*Journal of the Photographic Society.
*Journal of Society of Chemical Industry.
London, Edinburgh, and Dublin Philosophical Magazine.
Midland Naturalist.
*Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
Petermann's Mitteilungen.
Polytechnic Bibliothek.
*Proceedings of Royal Geographical Society.
*Proceedings of Royal Society of London.
*Proceedings of the Society of Biblical Archæology.
Revue Universelle des Mines.
*Royal Astronomical Society's Monthly Notices.
Sanitary Journal.
*Scottish Geographical Magazine.
Zoologist.

QUARTERLY.

Annales des Mines.
Annals of Botany.
*Archives Nèerlandaises des Sciences Exactes et Naturelles.
*Bulletin of the American Geographical Society.
Forschritte der Mathematik.
Grevillea.
Ibis.
Journal of Anatomy and Physiology.
*Journal of the Anthropological Institute of Great Britain.
*Journal of Manchester Geographical Society.

Journal of the Royal Agricultural Society of England.

*Journal of the Royal Statistical Society.

*Journal of the Scottish Meteorological Society.

La Nature.

Mind: a Quarterly Review of Psychology and Philosophy.

Quarterly Journal of Economics.

Quarterly Journal of Geological Society.

Quarterly Journal of Microscopical Science.

Quarterly Journal of Pure and Applied Mathematics.

*School of Mines Quarterly.

Scottish Naturalist.

*Sociedad Cientifica "Antonio Alzate."

Zeitschrift für Analytische Chemie.

LIST OF MEMBERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW,

FOR 1892-93.

HONORARY MEMBERS.

(Limited to Twenty.)

WITH YEAR OF ELECTION.

FOREIGN.

Hermann Ludwig Ferdinand von Helmholtz, Berlin. 1860
Rudolph Albert von Kölliker, Würtzburg. 1860
Ernst Heinrich Hæckel, Jena. 1880
Louis Pasteur, Paris. 1885
5 Georg Quincke, Heidelberg. 1890

AMERICAN AND COLONIAL.

James Dwight Dana, LL.D., Professor of Geology and Mineralogy in Yale College, Connecticut. 1860
Robert Lewis John Ellery, F.R.A.S., Victoria. 1874
Sir John William Dawson, LL.D., F.R.S., Principal of M'Gill College, Montreal. 1883
Thomas Muir, M.A., LL.D., F.R.S.E., Superintendent General of Education, Cape Colony. 1892

BRITISH.

10 Sir Joseph Dalton Hooker, K.C.B., K.C.S.I., M.D., D.C.L., LL.D., F.R.S., The Camp, Sunningdale. 1874
Thomas Henry Huxley, Ph.D., LL.D., D.C.L., F.R.S., Professor of Biology in the Royal College of Science, London, Hodeslea, Eastbourne. 1876
Herbert Spencer, care of Messrs. Williams & Norgate, 14 Henrietta street, Covent Garden, London. 1879
John Tyndall, LL.D., D.C.L., F.R.S., M.R.I., Hindhead House, Haslemere, Surrey. 1880
Rev. John Kerr, LL.D., Glasgow. 1885
15 Sir George Gabriel Stokes, Bart., M.A., LL.D., D.C.L., F.R.S., M.P., Cambridge. 1887
F. Max Müller, M.A., Professor of Comparative Philology, Oxford. . . . 1889
The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., *Sec.*R.S., London, Terling Place, Witham, Essex. 1890

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

Rev. H. W. Crosskey, LL.D., F.G.S., 117 Gough road, Birmingham. . . . 1874
A. S. Herschel, M.A., D.C.L., F.R.S., F.R.A.S., Hon. Professor of Experimental Physics in the Durham College of Science, Newcastle-on-Tyne; Observatory House, Slough, Bucks. 1874
Thomas E. Thorpe, Ph.D., F.R.S., Professor of Chemistry in Royal College of Science, London. 1874
John Aitken, F.R.S., F.R.S.E., Darroch, Falkirk. 1883
5 Alex. Buchan, M.A., LL.D., F.R.S.E., Secretary to the Scottish Meteorological Society, 122 George street, Edinburgh. 1883
James Dewar, M.A., F.R.S., F.R.S.E., M.R.I., Jacksonian Professor of Physics, University of Cambridge, and Professor of Chemistry in the Royal Institution of Great Britain, 1 Scroope terrace, Cambridge. 1883
Stevenson Macadam, Ph.D., F.R.S.E., Lecturer on Chemistry, Surgeons' Hall, Edinburgh. 1883
Joseph W. Swan, M.A., F.R.S., Lauriston, Bromley, Kent. 1883
E. A. Wünsch, F.G.S., Carharrack, Scorrior, Cornwall. 1883
10 George Anderson, Master of the Mint, Melbourne. 1885

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

* *Denotes Life Members.*

Adam, William, M.A., 235 Bath st. 1876
*Adam, Thomas, 27 Union street. 1892
Adams, William, 28 Ashton terrace, Dowanhill. 1891
Aikman, C. M., M.A., B.Sc., F.R.S.E., F.I.C., F.C.S., Lecturer on Agricultural Chemistry, Technical College, 183 St. Vincent street. 1886
5 Aitken, William, National Telephone Company. 1890
Alexander, D. M., 8 Royal crescent, Crosshill. 1887
Alexander, Peter, M.A., 26 Smith street, Hillhead. 1885
Alexander, Thos., 48 Sardinia ter. 1869
Alley, Stephen, Sentinel Works, Polmadie road. 1884
10 Alston, J. Carfrae, 27 James Watt street. 1887
Anderson, Alexander, 157 Trongate. 1869
Anderson, James, 168 George street. 1890
Anderson, John, 22 Ann street. 1884
Anderson, Robert, 22 Ann street. 1887
15 Anderson, R. T. R., 618 Gallowgate street. 1889
*Anderson, T. M'Call, M.D., Professor of Clinical Medicine in the University of Glasgow, 2 Woodside terrace. 1873
*Anderson, William, 284 Buchanan street. 1890
Anderson, W. F. G., 47 Union street. 1878
Annan, J. Craig, 234 Sauchiehall st. 1888
20 Annandale, Charles, M.A., LL.D., 86 Dixon avenue, Crosshill. 1888
Arnot, James Craig, 162 St. Vincent street. 1869
*Arnot, J. L., 116 West Campbell street. 1890
Arrol, William A., 16 Dixon street. 1869
Atkinson, J. B., 10 Foremount terrace, Partick. 1889

25 Bain, Andrew, 17 Athole gardens. 1890
Bain, Sir James, F.R.S.E., 3 Park terrace. 1866
Bain, Robert, 132 West Nile street. 1869
*Baird, J. G. A., M.P., Wellwood, Muirkirk. 1892
Balloch, Robert, 131 St. Vincent st. 1843
30 Balmain, Thos., 1 Kew terrace, Kelvinside. 1881
Barbour, T. F., F.C.S., F.I.C., 35 Robertson street. 1891
Barclay, A. P., 63 St. Vincent street. 1890
Barclay, George, 63 St. Vincent st. 1891
Barclay, James, 36 Windsor terrace. 1871
35 Barrett, Francis Thornton, Mitchell Library. 1880
Barr, Archibald, D.Sc., Professor of Civil Engineering and Mechanics, University of Glasgow, Royston, Dowanhill. 1890
*Barr, James, C.E., I.M., F.S.I., 221 West George street. 1883
Barr, Thos., M.D., F.F.P.S.G., 13 Woodside place, W. 1879
Bathgate, William, M.A., 13 Westbourne gardens. 1887
40 Bayne, A. Malloch, 13 Kelvin drive, Kelvinside. 1878

Beatson, George T., B.A. (Cantab.), M.D., 7 Woodside crescent. 1881
Begg, Wm., 636 Springfield road. 1883
*Beith, Gilbert, M.P., 7 Royal Bank place. 1881
Bell, Dugald, 27 Lansdowne cres. 1871
45*Bell, Henry, 5 Cornwall terrace, Regent's Park, London, N.W. 1876
Bell, Horatio, Westbank quadrant, Hillhead. 1892
Bell, James, 101 St. Vincent street. 1877
Bell, Stuart, 264 St. Vincent street. 1893
Bennett, Robert J., Alloway park, Ayr. 1883
50 Biles, J. H., Professor of Naval Architecture and Marine Engineering, University of Glasgow. 1893
Bilsland, William, 28 Park circus. 1888
Binnie, J., Barassie, Troon. 1877
Black, D. Campbell, M.D., M.R.C.S.E., 121 Douglas street. 1872
Black, J. Albert. Duneira, Row. 1869
55 Black, John, 16 Park terrace. 1869
Black, Malcolm, M.B., C.M., 5 Canning place. 1880
*Blackie, J. Alexander, 17 Stanhope street. 1881
*Blackie, J. Robertson, 17 Stanhope street. 1881
Blackie, Robert, 17 Stanhope st. 1847
60 Blackie, W. G., Ph.D., LL.D., F.R.G.S., 17 Stanhope street. 1841
*Blackie, Walter W., B.Sc., 17 Stanhope street. 1886
Blair, G. M'Lellan, 2 Lilybank ter. 1869
Blair, J. M'Lellan, Williamcraig, Linlithgowshire. 1869
Blair, Matthew, 11 Hampton Court terrace. 1887
65 Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy, Andersonian Buildings, 204 George street. 1881
*Blyth, Robert, C.A., 1 Montgomerie quadrant. 1885
Blythswood, Lord, Renfrew. 1885
Borthwick, James D., 3 Balshagray terrace, Partick. 1891
Bottomley, James T., M.A., D.Sc., F.R.S., F.R.S.E., F.C.S., Demonstrator in Natural Philosophy, University of Glasgow, 13 University gardens, Hillhead, *Vice-President*. 1880
70 Bottomley, Wm., C.E., 15 University gardens. 1880
Bower, F. O., D.Sc., M.A., F.R.S., F.L.S., Regius Professor of Botany in the University of Glasgow, 45 Kersland terrace. 1885
Boyd, John, Shettleston Iron-works, near Glasgow. 1873
Brand, James, C.E., 172 Buchanan street. 1880
Brier, Henry, M.I.M.E., Scotch and Irish Oxygen Co., Polmadie. 1889
75 Brodie, John Ewan, M.D., C.M., F.F.P.S.G., 1 Albany place. 1873
Brodie, Maclean, C.A., 44 Westbourne gardens. 1889
*Brown, Alexander, 3 Queen's ter. 1887
Brown, Hugh, 5 St. John's terrace, Hillhead. 1887
Brown, James, 76 St. Vincent st. 1876
80*Brown, John, 11 Somerset place. 1881
Brown, Robert, 19 Jamaica street. 1882
*Brown, Wm. Stevenson, 41 Oswald street. 1886
*Brown, William, 165 W. George st. 1892
Browne, Richard, Beechholm, Queen's drive, Crosshill. 1893
85 Browne, Robert, B.Sc., 45 Washington street. 1893
Brownlie, Archibald, Bank of Scotland, Barrhead. 1880
Brownlie, J. Rankin, L.D.S. (Eng.), 220 West George street. 1892
Brunton, Rev. Alex., Ardbeg villa, Craigpark, Dennistoun. 1884
*Bryce, Charles C., 141 West George street. 1884
90 Bryce, David, 129 Buchanan street. 1872
*Bryce, Robert, 82 Oswald street. 1886
*Buchan, William P., 36 & 38 Renfrew street. 1875
Buchanan, Alex. M., A.M., M.D., Professor of Anatomy, Anderson's College Medical School, 98 St. George's road. 1876
Buchanan, George S., 85 Candleriggs. 1845
95*Buchanan, William, 123 Blythswood drive. 1886
Burnet, John, I.A., 167 St. Vincent street. 1850
Burnet, John James, A.R.I.B.A., 18 University avenue. 1892
Burnet, Lindsay, Assoc. M.I.C.E., St. Kilda, Dowanhill. 1882
Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864

100*Caldwell, George B., Scotia Leather Works, Boden street. 1892
Callajon, Ventura De, 131 West Regent street. 1886
Callajon, Ventura De, jun., 7 Woodlands terrace. 1891
Cameron, Sir Charles, M.D., LL.D., M.P., Greenock. 1870
Cameron, H. C., M.D., 200 Bath street. 1873
105 Cameron, John E., 115 Bothwell st. 1892
Cameron, R., Wellpark, Bathgate. 1873

*Campbell, J. A., LL.D., M.P., Strathcathro, Brechin. 1848
*Campbell, James, 137 Ingram st. 1885
Campbell, John D., Greenside, North avenue, Copeland road, Govan. 1858
110 *Campbell, John Ferguson, 2 Lugar place. 1892
Campbell, John MacNaught, C.E., F.Z.S., F.R.S.G.S., Kelvingrove Museum. 1883
*Campbell, Louis, 3 Eton terrace, Hillhead. 1881
Carlile, Thomas, 23 West Nile street. 1851
Carmichael, Neil, M.D., C.M., F. F. P. S. G., Invercarmel, 23 Nithsdale drive, Pollokshields. 1873
115 Carver, Thomas, A.B., B.Sc., C.E., 11 University. 1890
Cassells, John, 62 Glencairn drive, Pollokshields. 1890
*Cayzer, Charles W., 109 Hope street. 1886
Chalmers, A. K., M.D., D.P.H. (Camb.), 4 Rosebery terrace, Kelvinbridge. 1892
Chalmers, James, I.A., 101 St. Vincent street. 1884
120 Chalmers, P. Macgregor, F.S.A.Scot., 176½ Hope street. 1891
Cherrie, James M., Clutha cottage, Tollcross. 1876
*Chisholm, Samuel, 4 Royal ter., W. 1890
*Christie, Henry W., Levenfield house, Alexandria. 1892
Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
125 Chrystal, W. J., F.I.C., F.C.S., Shawfield Works, Rutherglen. 1882
Church, W. R. M., C.A., 75 St. George's place. 1885
Clapperton, Charles, 175 West George street. 1882
Clapperton, John, 9 Crown Circus drive. 1874
Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
130 Clark, John, 9 Wilton crescent. 1872
*Clark, William, 125 Buchanan st. 1876
Clavering, Thos., 27 St. Vincent place. 1856
Cleland, A. B. Dick, 15 Newton place. 1871
*Cleland, John, M.D., LL.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 1884
135 *Coats, Joseph, M.D., 31 Lynedoch street. 1873
*Cochran, Robert, 7 Crown circus, Dowanhill. 1877
Coghill, Wm. C., 263 Argyle street. 1873
Collins, Sir William, F.R.G.S., 3 Park terrace, East. 1869
Colquhoun, James, LL.D., 158 St. Vincent street. 1876
140 Colville, James, M.A., D.Sc., 14 Newton place. 1885
Combe, William, 257 W. Campbell street. 1877
Connell, Wm., 42 St. Enoch square. 1870
Copland, Wm. R., M. Inst. C.E., F.S.I., 146 West Regent street. 1876
Core, William, M.D., Medical Superintendent, Barnhill Hospital. 1891
145 Coste, Jules, French Consulate, 131 West Regent street. 1888
Costigane, John T., Hampton house, Ibrox. 1889
Costigane, William, Clifton house, Pollokshields. 1890
Coubrough, A. Sykes, Parklea, Blanefield, Strathblane. 1869
Coulson, W. Arthur, 57 West Nile street. 1888
150 Couper, James, Craigforth house, Stirling. 1862
Cowan, M'Taggart, C.E., 27 Ashton terrace, Hillhead. 1876
Craig, T. A., C.A., 139 St. Vincent street. 1886
Crawford, Robert, 84 Miller st. 1886
Crawford, Wm. C., M.A., Lockharton gardens, Slateford, Edinburgh. 1869
155 Cree, Thomas S., 21 Exchange sq. 1869
Crighton, James, 47 Nithsdale drive, Pollokshields. 1892
Crosbie, L. Talbot, Scotstounhill, Whiteinch. 1890
Cross, Alexander, 14 Woodlands terrace. 1887
Cruikshank, George M., 62 St. Vincent street. 1885
160 Cunningham, John M., 18 Woodside terrace. 1881
Cunningham, J. R., jun., 27 Oswald street. 1881
Curphey, Wm. Salvador, 15 Bute mansions, Hillhead 1883
Cuthbert, Alexander A., 14 Newton terrace. 1885
*Cuthbertson, Sir John N., 29 Bath street. 1850

165 Dansken, A. B., 179 West George street. 1877
*Dansken, John, I.M., F.S.I., F.R.A.S., 121 West Regent st. 1876
Darling, Geo. E., 178 St. Vincent st. 1870
Darwin, Harry, St. Andrew's Works, 618 Eglinton street. 1891
Deas, Jas., C.E., 7 Crown gardens, Dowanhill. 1869

170 Dempster, John, 4 Belmar terrace, Pollokshields. 1875
Dennison, William, C.E., 175 Hope street. 1876
Dewar, Duncan, St. Fillans, West Coates, Cambuslang. 1877
*Dick, George Handasyde, 136 Buchanan street. 1887
*Dixon, A. Dow, 10 Montgomerie crescent, Kelvinside. 1873
175 Dixon, Walter, 7 Bothwell street. 1893
Dobbie, A. B., M.A., University. 1885
Dobson, James, Springfield avenue, Uddingston. 1892
Donald, John, Townhead Public School. 1872
Donald, William J. A., 70 Great Clyde street. 1877
180 Donaldson, James, Gas-works, Cambuslang. 1890
Dougall, Franc Gibb, 167 Canning street. 1875
Dougall, John, M.D., C.M., F.F.P.S.G., Professor of Materia Medica, St. Mungo's College, 6 Belmar terrace, Pollokshields. 1876
Douglas, Campbell, I.A., F.R.I.B.A., 266 St. Vincent street. 1870
Downie, Robert, jun., Carntyne Dye-works, Parkhead. 1872
185 Downie, Thomas, Hydepark Foundry. 1886
Drew, Alex., 12 St. Vincent place. 1869
Duncan, Eben., M.D., C.M., F.F.P.S.G., Queen's Park house, Langside road. 1873
*Duncan, Robert, Whitefield Works, Govan. 1890
*Duncan, Walter, 7 West George st. 1881
190*Dunlop, Nathaniel, 25 Bothwell street. 1870
Dunn, Robert Hunter, 4 Belmont crescent. 1878
Dyer, Henry, M.A., D.Sc., C.E., 8 Highburgh terrace, Dowanhill. 1883

Eadie, Alexander, 280 Cathcart road. 1885
Easton, William J., 150 West Regent street. 1876
195*Edwards, John, Govanhaugh Dye-works, M'Neil street. 1883
Edwards, Matthew, 209 Sauchiehall street. 1887
Elgar, Francis, LL.D., Fairfield Works, Govan. 1884
*Ellis, T. Leonard, North British Iron-works, Coatbridge. 1888
Erskine, Jas., M.A., M.B., L.F.P.S., 5 Charing Cross mansions. 1886
200*Ewing, Wm., 7 Royal Bank place. 1883

Fairweather, Wallace, C.E., 62 St. Vincent street. 1880
Falconer, Patrick, 33 Hayburn crescent, Partick. 1876
Falconer, Thos., 50 Kelvingrove st. 1880
Farquhar, John, 13 Belhaven ter. 1872
205 Farquhar, Wm. R., 13 Belhaven terrace. 1892
Faulds, W. B., Westfield, Ibrox. 1890
Fawsitt, Charles A., 9 Foremount terrace, Partick. 1879
Fergus, Freeland, M.D., F.F.P.S.G., 3 Elmbank crescent. 1887
Ferguson, D. Scott, 10 Belhaven terrace. 1890
210*Ferguson, John, M.A., LL.D., F.R.S.E., Professor of Chemistry, University of Glasgow, *President*. 1869
Ferguson, Peter, 15 Bute gardens, Hillhead. 1866
Ferguson, Thomas, 124 Salamanca street, Parkhead. 1883
Fergusson, Alex. A., 48 M'Alpine street. 1847
Fife, William, 52 Glassford street. 1880
215 Finlay, H. G., 16 Westbourne terrace. 1888
Findlay, Joseph, Clairmont, Winton drive, Kelvinside. 1873
Finlayson, James, M.D., 2 Woodside place. 1873
*Fleming, James, 136 Glebe street. 1880
*Fleming, William James, M.D., 3 Woodside terrace. 1876
220 Fotheringham, T. B., 65 West Regent street. 1889
Foulis, William, C.E., 45 John st. 1870
*Fowler, John, 5 Derby street, Sandyford. 1880
Frame, James, Union Bank of Scotland, 113 King street, Tradeston. 1885
Fraser, Matthew P., 91 W. Regent street. 1887
225 Fraser, Melville, 31 St. Vincent pl. 1890
Frazer, Daniel, 127 Buchanan st. 1853
Frew, Alex., C.E., 175 Hope street. 1876
Fullarton, J. H., M.A., B.Sc., Fishery Board Office, Edinburgh. 1886
Fullerton, Robert, M.D., 24 Newton place. 1892
230 Fulton, David, Roxburgh villa, Bothwell. 1891
Fulton, R. C., 2 Lugar place, Kelvinside. 1890
Fyfe, Henry B., 115 St. Vincent street. 1892
Fyfe, Peter, 1 Montrose street. 1886

Gairdner, Charles, LL.D., Broom, Newton-Mearns. 1884
235*Gairdner, C. D., C.A., 115 St. Vincent street. 1886

Gairdner, W. T., M.D., LL.D., Professor of Practice of Medicine in the University of Glasgow, 225 St. Vincent street. 1863
Galbraith, Peter, 17 Huntly gardens. 1889
Gale, James M., C.E., 45 John street. 1856
Galloway, T. Lindsay, C.E., 43 Mair street, Plantation. 1881
240 Gardner, Daniel, 36 Jamaica street. 1869
*Garrow, James R., 32 Elmbank crescent. 1890
*Garroway, John, 694 Duke st. 1875
Geddes, Wm., 8 Battlefield crescent, Langside. 1846
Gillies, W. D., 17 Royal Exchange square. 1872
245 Gilfillan, Wm., 129 St. Vincent st. 1881
Glaister, John, M.D., F.F.P.S.G., D.P.H., Camb., &c., Professor of Medical Jurisprudence and Public Health, St. Mungo's College, 4 Grafton place. 1879
Goldie, James, 40 St. Enoch square. 1883
Goodwin, Robert, 58 Renfield street. 1875
Gorman, C. S., Beechwood, Mount Vernon. 1890
250 Gourlay, John, C.A., 24 George sq. 1874
Gow, Leonard, 19 Waterloo street. 1889
Gow, Leonard, jun., 19 Waterloo street. 1884
Gow, Robert, Cairndowan, Dowanhill gardens. 1860
Graham, Alex. M., Rowanlea, 7 St. Andrew's drive, Pollokshields. 1887
255 Graham, Robert, 108 Eglinton st. 1888
*Graham, William, 11 Claremont terrace. 1885
Gray, Andrew, 30 Bath street. 1889
Gray, James, M.D., 15 Newton terrace. 1863
Greenlees, Alex., M.D., 33 Elmbank street. 1864
260 Grieve, John, M.A., M.D., F.R.S.E., care of W. L. Buchanan, 212 St. Vincent st. 1856
Griffiths, Azariah, Elmbank, Falkirk. 1886
Guthrie, John, 50 M'Culloch st. 1891

Halket, George, M.D., F.F.P.S.G., 4 Royal cres., W. 1889
*Hamilton, John, I.A., 212 St. Vincent street. 1885
265 Harley, George, 29 Burnbank gar. 1891
*Harvie, John, Secretary, Clydesdale Bank, 30 St. Vincent place. 1880
Harvie, William, 8 Bothwell terrace, Hillhead. 1888
Hay, Alexander, 56 George square. 1892
Hedderwick, Maxwell, 3 Woodside place. 1892
270 *Henderson, A. P., 20 Newton place. 1880
Henderson, George G., D.Sc., M.A., F.I.C., F.C.S., Professor of Chemistry, Glasgow and West of Scotland Technical College, 204 George street. 1883
*Henderson, John, jun., Meadowside Works, Partick. 1879
Henderson, John, Towerville, Helensburgh. 1890
Henderson, Robert, 330 Renfrew street. 1885
275 Henderson, Thomas, 47 Union street. 1855
*Henderson, Wm., 4 Windsor terrace, West. 1873
Henry, R. W., 8 Belhaven crescent, Kelvinside. 1875
Heys, Zechariah J., South Arthurlie, Barrhead. 1870
Higginbotham, Robert Ker, 4 Springfield court, 69 Queen st. 1885
280 Higgins, Henry, jun., 247 St. Vincent street. 1878
Hodge, William, 27 Montgomery drive, Kelvinside. 1878
Hogg, Robert, 9 Nithsdale drive, Pollokshields. 1865
Honeyman, John, F.R.I.B.A., 140 Bath street. 1870
Horne, R. R., C.E., 150 Hope st. 1876
285 Horton, William, Birchfield, Mount Florida. 1889
Howat, William, 37 Elliot street. 1885
Howatt, James, I.M., 146 Buchanan street. 1870
Howatt, William, I. M., 146 Buchanan street. 1870
Hunt, Edmund, 87 St. Vincent st. 1856
290 *Hunt, John, Milton of Campsie. 1881
*Hunter, Wm. S., 30 Hope street. 1889
Hutchison, Peter, 3 Lilybank terrace, Hillhead. 1889

Inglis, R. A., Culrain, Bothwell. 1889

*Jack, William, M.A., LL.D., Professor of Mathematics in the University of Glasgow. 1881
295 Jamieson, Andrew, F.R.S.E., M.Inst.C.E., M.Inst.E.E., &c., Professor of Engineering, 38 Bath street. 1881
Jenkins, Thomas Wilson, M.A., M.D., 232 Kenmure street. 1892
Johnston, David, 160 West George street. 1891
Johnstone, Jas., Coatbridge street, Port-Dundas. 1869

Jolly, William, F.G.S., F.R.S.E., Greenhead house, Govan. 1890

300 Kay, Wm. E., F.C.S., Gowanbank, Clarkston, Busby. 1887
Kean, James, 32 Scotia street, Garnethill. 1888
Kelly, James K., M.D., F.F.P.S.G., Park villa, Queen Mary avenue, Crosshill. 1889
Kelvin, The Right Hon. Lord, LL.D., D.C.L., *P*.R.S., F.R.S.E., Professor of Natural Philosophy, University of Glasgow, *Hon Vice-President*. 1846
Kennedy, Hugh, Redclyffe, Partick. 1876
305 Kennedy, James, 33 Greendyke st. 1889
Ker, Charles, M.A., C.A., 115 St. Vincent street. 1885
*Ker, Wm., 1 Windsor ter., west. 1874
Kerr, Adam, 175 Trongate. 1887
Kerr, Charles James, 40 West Nile street. 1877
310 Kerr, Geo. Munro, 97 Buchanan street. 1890
Kerr, James Hy., 13 Virginia st. 1872
Kerr, John G., M.A., 15 India st. 1878
Key, William, 109 Hope street 1877
King, James, 57 Hamilton drive, Hillhead. 1848
315 King, Sir James, Bart., LL.D., of Campsie, 115 Wellington street. 1855
King, John Y., 142 St. Vincent st. 1893
Kirk, Robert, M.D., Newton cottage, Partick. 1877
Kirkpatrick, Alexander B., 88 St. Vincent street. 1885
Kirkpatrick, Andrew J., 179 West George street. 1869
320 Kirkwood, James, Carling lodge, Ibrox. 1890
Knight, James, M.A., B.Sc., 121 Kenmure street, Pollokshields. 1893
Knox, Adam, 47 Crownpoint road. 1881
*Knox, David J., 19 Renfield street. 1890
Knox, John, 58 Bath street. 1883

325 Laird, George H., 159 Greenhead street. 1882
Laird, John, Marchmont, Port-Glasgow. 1876
Laird, John, Royal Exchange Sale Rooms. 1879
Lamb, Thomas, 220 Parliamentary road. 1870
Lang, William, jun., F.C.S., Crosspark, Partick. 1865
330 Latta, James, 73 Mitchell street. 1869
*Lauder, James, F.R.S.L., Glasgow, Athenæum. 1892
Leitch, Alexander, 60 Rosebank terrace, Grant street. 1886
*Lindsay, Archd. M., M.A., 87 West Regent street. 1872
Love, James Kerr, M.D., C.M., 4 Matilda place, Strathbungo. 1888
335 Lundholm, C. O., Nobel's Explosives Factory, Ardeer, Stevenston. 1890

M'Ara, Alex., 65 Morrison street. 1888
Macarthur, J. G., Rosemary villa, Bowling. 1874
*MacArthur, John S., 13 West Scotland street. 1890
M'Call, Samuel, 16 Hillsborough square, Hillhead. 1882
340 M'Callum, Robert, jun., 69 Unionst. 1891
*M'Clelland, Andrew Simpson, C.A., 4 Crown gardens, Dowanhill. 1884
M'Conville, John, M.D., 27 Newton place. 1870
M'Cracken, James, 5 Bowmont terrace, Kelvinside. 1889
M'Crae, John, 7 Kirklee gardens, Maryhill. 1876
345 M'Creath, James, M.E., 208 St. Vincent street. 1874
M'Culloch, Hugh, 154 West Regent street. 1880
Macdonald, Archibald G., 8 Park circus. 1869
Macdonald, Thomas, 205 St. Vincent street. 1869
Macdonald, Thomas F., M.B., C.M., Burgh house, Maryhill. 1889
350 Macfarlane, Walter, Crosslea house, Thornliebank. 1869
*Macfarlane, Walter, 12 Lynedoch crescent. 1885
M'Farlane, Wm., Edina lodge, Rutherglen. 1888
*M'Gilvray, R. A., 129 West Regent street. 1880
M'Gregor, Duncan, F.R.G.S., 37 Clyde place. 1867
355 M'Gregor, James, 1 East India avenue, London, E.C. 1872
M'Houl, David, Ph.D., Dalquhurn Works, Renton. 1883
M'Intyre, Wm., Marion bank, Rutherglen. 1888
Mackay, John Yule, M.D., 34 Elmbank crescent. 1885
M'Kellar, J., 25 Kelvinside ter., 1893
360*M'Kenzie, W. D., 43 Howard st. 1875
*M'Kenzie, W. J., 1 Oakfield ter., Hillhead. 1879
*M'Kendrick, John G., M.D., C.M., LL.D., F.R.S., F.R.S.E., F.R.C.P.E., Professor of Institutes of Medicine in the University of Glasgow, 2 Florentine gardens. 1877

Mackinlay, David, 6 Great Western terrace, Hillhead. 1855
*Mackinlay, James Murray, 4 Westbourne gardens. 1886
365 Mackinlay, Wm., 2 Belmont crescent., Hillhead. 1887
M'Kissack, John, 68 West Regent street. 1881
Maclae, A. Crum, 147 St. Vincent street. 1884
*Maclay, David T., 169 W. George st. 1879
Maclay, W., Eildon villas, Mount Florida. 1893
370 Maclean, A. H., 8 Hughenden terrace, Kelvinside. 1870
Maclean, Magnus, M.A., F.R.S.E., 8 St. Albans terrace, Hillhead. 1885
MacLehose, James J., M.A., 61 St. Vincent street. 1882
M'Lennan, James, 40 St. Andrew's street. 1888
Macouat, R. B., 37 Elliot street 1885
375 Macphail, Donald, M.D., Garturk cottage, Whifflet, Coatbridge. 1877
M'Pherson, George L., 26 Albert road, Crosshill, East. 1872
M'Vail, D. C., M.B., 3 St. James' terrace, Hillhead. 1873
M'Whirter, William, Faraday Electrical Works, Govan. 1889
Machell, Thomas, 39 Great Western road. 1886
380 Main, Robert B., Broompark, Ardrossan. 1885
Mann, John, C.A., 188 St. Vincent street, *Treasurer*. 1856
Mann, John, jun., M.A., C.A., 188 St. Vincent street. 1885
Manwell, James, The Hut, 4 Albert drive, Pollokshields. 1876
Martin, William, 116 St. Vincent street. 1892
385 Martin, W. C., 342 Argyle street. 1889
Marwick, Sir J. D., LL.D., F.R.S.E., 19 Woodside terrace. 1878
Mathieson, Thomas A., 3 Grosvenor terrace. 1869
Mavor, Alfred E., Victoria mansions, 32 Victoria street, London, S.W. 1890
Mavor, Henry A., 57 West Nile street. 1887
390 *Mavor, James, 63 Bank street, Hillhead. 1885
Mavor, Samuel, 4 Elmbank cres. 1890
Mayer, John, Strathview, Cathkin road, Langside, *Secretary*. 1860
Mechan, Arthur, 60 Elliot street. 1876
Mechan, Henry, 60 Elliot street. 1879
395 Meikle, Andrew W., M.A., Viewfield house, Pollokshields. 1890
Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
*Menzies, Thos. J., M.A., B.Sc., F.C.S., Stranraer Academy, Stranraer. 1887
Millar, James, 158 Parliamentary rd. 1870
Miller, A. Buchanan, 13 North Claremont street. 1891
400 Miller, A. Lindsay, 124 Bath street. 1878
*Miller, Arch. Russell, 28 Lilybank gardens, Hillhead. 1884
Miller, David S., 8 Royal crescent, W. 1887
*Miller, George, Winton drive, Kelvinside. 1881
Miller, G. J., Frankfield, Shettleston. 1888
405 Miller, John (Messrs. James Black & Co.), 23 Royal Exchange square. 1874
Miller, Richard, 54 St. Enoch sq. 1885
*Miller, Thos. P., Cambuslang Dyeworks. 1864
Miller, W. M., 7 Mansfield place, West Regent street. 1867
Milligan, Thomas R., 22 Arlington street. 1892
410 Mills, Edmund J., D.Sc., F.R.S., "Young" Professor of Technical Chemistry, 60 John street. 1875
Milne, William, M.A., B.Sc., F.R.S.E., High School. 1881
Mirrlees, James B., Redlands, Kelvinside. 1869
*Mirrlees, William J., 42 Aytoun road, Pollokshields. 1889
*Mitchell, George A., 67 West Nile street. 1883
415 Mitchell, Robert, 12 Wilson street, Hillhead. 1870
*Moffatt, Alexander, 23 Abercromby place, Edinburgh. 1874
Moir, Charles S., 92 Union street. 1884
Mollison, James, 6 Hillside gardens, Partick. 1889
*Mond, Robert Ludwig, B.A. (Cantab), F.R.S.E., 20 Avenue road, Regent's park, London, N.W. 1890
420 *Monteith, Robert, Greenbank, Dowanhill gardens. 1885
Moore, Alexander, C.A., 209 West George street. 1869
Moore, Alexander George, M.A., B.Sc., 13 Clairmont gardens. 1886
Morgan, John, Springfield house, Bishopbriggs. 1844
Morrice, Jas. A., 1 Athole gardens place. 1883
425 Motion, James Russell, 38 Cochrane street. 1887
Muir, Alex., 400 Eglinton street. 1883
*Muir, Allan, 36 George street. 1881
Muir, James, C.A., 149 West George street. 1887

Muir, Sir John, Bart., 22 West Nile Street. 1876
430 *Muirhead, Andrew Erskine, Cart Forge, Crossmyloof. 1873
Muirhead, James, 10 Doune gardens, Kelvinside. 1887
*Muirhead, Robert F., M.A., B.Sc., Woodlands, Bridge-of-Weir. 1879
Munro, Daniel, F.S.I., 10 Doune terrace, Kelvinside. 1867
Munro, John, 69 Bank st., Hillhead. 1893
435 Munsie, George, 1 St. John's ter., Hillhead. 1871
Munsie, Robert George, 10 Berkeley terrace, West. 1883
*Murdoch, Robert, 19 Commerce st. 1880
Murdoch, Thomas, 115 Bothwell street. 1892
*Murray, David, LL.D., 169 West George street. 1876
440 Murray, John Bruce, 24 George square. 1890
Murray, A. Erskine, Sheriff-Substitute of Lanarkshire, Sundown, Montgomerie drive. 1881
Murrie, James, 12 Houldsworth street. 1892

Napier, Alex., M.D., F.F.P.S.G., Rose Bank, Queen Mary avenue, Crosshill. 1886
Napier, James, 15 Prince's square, Strathbungo. 1870
445 *Napier, John, 23 Portman square, London. 1846
Nelson, Alex., 80 Gordon street. 1880
Nelson, D. M., 68 Bath street. 1875
*Newlands, Joseph F., 28 Renfield st. 1883
Nisbet, Robert, Star Foundry, Kinning Park. 1890

450 Ogilvie, William, 1 Doune terrace. 1881
Orr, Robert, 79 West Nile street. 1890
Osborne, Alex., 5 Oakley terrace, Dennistoun. 1870
Osborne, Robert, 3 Montgomerie crescent. 1890
Outram, D. E., 16 Grosvenor ter., Hillhead. 1878

455 Park, James, 51 Millburn street. 1877
*Parker, John Dunlop, C.E., 146 West Regent street. 1889
*Parnie, James, F.S.I. 32 Lynedoch street. 1874
*Paterson, Robert, C.A., 28 Renfield street. 1881
Paton, James, F.L.S., Corporation Galleries, and Kelvingrove Museum. 1876
460 Patterson, T. L., F.C.S., at John Walker & Co.'s, Greenock. 1873

Petrie, Alexander, I.A., 134 Wellington street. 1885
Pirie, John, M.D., 26 Elmbank crescent. 1877
*Pirrie, Robert, 9 Buckingham ter. 1875
*Pollock, R., M.B., C.M., F.F.P.& S.G., Laurieston house, Pollokshields. 1883
465 Pride, David, M.D., Townhead House, Neilston. 1887
Prince, Edward E., B.A. (Cantab), F.L.S., Professor of Zoology, St. Mungo's College. 1892
Pringle, Patrick James, 115 Mains street. 1892
*Provan, James, 40 West Nile st. 1868
Provand, A. D., M.P., 8 Bridge street, London, S.W. 1888

470 Raalte, Jacques Van, 104 West George street. 1884
Ramsay, Robert, M.D., L.R.C.S.E., Lochwinnoch. 1881
Ramsey, Robert, 14 Park terrace. 1889
Rankine, David, C.E., 5 West Regent street. 1875
Rattray, Rev. Alex., M.A., Parkhead parish, 4 Westercraigs, Dennistoun. 1879
475 Rattray, William A., 233 Hope st. 1890
Reid, Andrew, Houston place, S.S. 1875
Reid, David, 16 Cambridge street. 1887
*Reid, Hugh, Belmont, Springburn. 1880
Reid, James, 10 Woodside terrace. 1870
480 Reid, James, 15 Montgomerie cres. 1889
Reid, Thos., M.D., 11 Elmbank st. 1869
Reid, William, M.A., 51 Grant st. 1881
*Reid, William L., M.D., 7 Royal crescent, West. 1882
Reith, Rev. George, M.A., D.D., Free College Church, 37 Lynedoch st. 1876
485 Renton, James Crawford, M.D., L.R.C.P.&S.Ed., 1 Woodside ter. 1875
Rey, Hector, B.L., B.Sc., 2 Vinicombe street, Hillhead. 1889
Richmond, Thos., L.R.C.P.E., 2 West Garden street. 1887
Ritchie, George, Parkhead Forge and Steel Works. 1890
Robertson, John, 10 Valeview ter., Langside, *Librarian*. 1860
490 Robertson, J. M'Gregor, M.A., M.B., C.M., 26 Buckingham ter., Hillhead. 1881
Robertson, Robert, Coplawhill, Pollokshaws road. 1877
Robertson, Robert A., 8 Park Circus place. 1877
Robertson, Robert H., Clyde bank, Rutherglen. 1888
Robertson, William, C.E., 123 St. Vincent street. 1869
495 *Rogers, John C., 224 St. Vincent st. 1888

Rose, Alexander, Richmond house, Dowanhill. 1879
*Rose, Charles A., 1 Belhaven cres. 1889
Ross, David, M.A., B.Sc., LL.D., E.C. Training College. 1888
Ross, Henry, 7 Park quadrant. 1876
500 *Ross, John, 9 Westbourne gardens. 1885
Ross, William, 44 South Portland street. 1893
Rottenburg, Paul, 21 St. Vincent place. 1872
Rowan, David, 22 Woodside place. 1863
Rowan, W. G., 234 West George street. 1881
505 Rundell, R. Cooper, Underwriters' Room, Royal Exchange. 1877
Russell, James B., B.A., M.D., LL.D., 3 Foremount terrace, Partick, *Hon. Vice-President.* 1862

Salmon, W. Forrest, F.R.I.B.A., 197 St. Vincent street. 1870
Sayers, William Brooks, 56 George square. 1890
Schmidt, Alfred, 508 New City road. 1881
510 Scott, Alex., 2 Lawrence place, Dowanhill. 1871
*Scott, D. M'Laren, 2 Park quadrant. 1881
Scott, John, 140 Douglas street. 1891
Scott, John, 245 Sauchiehall st. 1892
Scott, Robt., I.M., 115 Wellington st. 1884
515 Scott, Thomas, 2 Teviot terrace, Kelvinside. 1893
Seligmann, Hermann L., 24 George square. 1850
Sexton, A. Humboldt, F.C.S., F.I.C., F.R.S.E., Professor of Metallurgy, Glasgow and West of Scotland Technical College, 204 George street. 1892
Shields, Thomas, M.A., Royal Indian Engineering College, Cooper's hill, Staines. 1890
Simons, Michael, 206 Bath street. 1880
520 Simpson, P. A., M.A. (Cantab.), M.D., Regius Professor of Forensic Medicine, University, 216 West George street. 1881
Sinclair, Alexander, Ajmere lodge, Langside. 1883
Sloane, F. N., C.A., 187 West George street. 1893
Smart, William, M.A., LL.D., Nunholm, Dowanhill. 1886
Smellie, George, I.M., 167 St. Vincent street. 1880
525 *Smellie, Thos. D., F.S.I. 209 St. Vincent street. 1871
Smith, D. Johnstone, C.A., 149 W. George street. 1888
Smith, Francis, Ashfield, Bothwell. 1875
Smith, Harry J., Ph.D., Coltness Iron-works, Newmains. 1877
Smith, Hugh C., 55 Bath street. 1861
530 Smith, James, LL.D., St. Peter's Lodge, Uddingston. 1892
*Smith, J. Guthrie, 54 West Nile st. 1875
*Smith, Robert B., Bonnybridge, Stirlingshire. 1884
Snodgrass, James, F.C.S., 2 Keir terrace, Pollokshields. 1878
Snodgrass, William, M.A., M.B., C.M., Muirhead Demonstrator of Physiology, University of Glasgow, 11 Victoria crescent, Dowanhill. 1890
535 *Somerville, Alexander, B.Sc., F.L.S., 4 Bute Mansions, Hillhead street, Hillhead. 1888
Somerville, Graham L., B.L., 58 W. Regent street. 1892
Sorley, Robert, 3 Buchanan st. 1878
Spencer, Charles L., Edgehill, Kelvinside. 1891
Spens, John A., 169 W. George st. 1879
540 *Spiers, John, 43 Great Western road, Hillhead. 1885
Stanford, Edward C. C., F.C.S., Glenwood, Dalmuir, Dumbartonshire. 1864
*Steel, William Strang, Philiphaugh, Selkirk. 1889
*Stephen, John, Domira, Partick. 1880
Stephen, Robt. R., Adelphi Biscuit Factory. 1867
545 *Steven, Hugh, Westmount, Montgomerie drive. 1869
Steven, John, 32 Elliot street. 1875
*Stevenson, D. M., 12 Waterloo street. 1889
*Stevenson, Jas., F.R.G.S., 23 West Nile street. 1870
Stevenson, John, C.E., 208 St. Vincent street. 1885
550 Stevenson, John, 12 Victoria road, Lenzie. 1892
Stevenson, William, Tower bank, Lenzie. 1870
Stevenson, Wm., 21 Clyde place. 1888
Stewart, Andrew, 41 Oswald street. 1887
Stewart, Archibald, 20 Balmoral crescent, Crosshill. 1892
555 Stewart, David, 3 Clifton place. 1856
Stewart, James, 2 Lawrence place, Dowanhill. 1891
Stewart, James Reid, 30 Oswald street. 1845
Stewart, John, Western Saw Mills. 1877
Stobo, Thomas, Somerset house, Garelochhead. 1884
560 Stoddart, James Edward, Howden, Mid-Calder, N.B. 1872

*Strain, John, C.E., 154 West George street. 1876
Summers, John, 174 West Nile st. 1891
*Sutherland, David, Royal Marine Hotel, Nairn. 1880
*Sutherland, John, Great Western Hotel, Oban. 1880
565 Sutherland, J. R., C.E., 45 John street. 1884
Sutherland, Malcolm, Leven Shipyard, Dumbarton. 1890
Sutherland, Robert, 28 Woodside place. 1875
Swan, Charles C., 15 Rose street, Garnethill. 1891

Tatlock, John, F.I.C., 13 Parkgrove terrace, West, Sandyford. 1875
570 Tatlock, Robt. R., F.R.S.E., F.I.C., F.C.S., 156 Bath street. 1868
Taylor, Benjamin, F.R.G.S., 10 Derby crescent, Kelvinside. 1872
Taylor, Thomas, 60 Montrose street. 1889
Teacher, Adam, 14 St. Enoch sq. 1868
Tennant, Sir Charles, Bart., 195 West George street. 1868
575 Tennent, Gavin P., M.D., 159 Bath street. 1875
Thomas, Moses, M.D., Superintendent, Royal Infirmary. 1890
Thomson, David, I.A., F.R.I.B.A., 2 West Regent street. 1869
Thomson, George C., F.C.S., 23 Kersland terrace, Hillhead. 1883
Thomson, Gilbert, M.A., C.E., 75 Bath street. 1885
580 Thomson, Graham Hardie, 2 Marlborough terrace, Kelvinside. 1869
*Thomson, James, F.R.I.B.A., 88 Bath street. 1886
Thomson, James, F.G.S., 26 Leven street, Pollokshields. 1863
Thomson, James M., Glen Tower, Kelvinside. 1892
Thorne, George, jun., 104 West George street. 1891
585 Townsend, C. W., Crawford street, Port-Dundas. 1890
*Tullis, James Thomson, Anchorage, Burnside, Rutherglen. 1883
*Turnbull, John, jun., M.I.M.E., 18 Blythswood square. 1883
Turner, George A., M.D., 1 Clifton place, Sauchiehall street. 1883
Turner, William, Rachan house, Helensburgh, N.B. 1875

590 Ure, William P., Regent Mills, Sandyford. 1893

Verel, Wm. A., The Linn, Cathcart. 1883

Walker, Adam, 35 Elmbank cres. 1880
*Walker, Archibald, B.A. (Oxon.), F.C.S., 8 Crown ter., Dowanhill. 1885
Walker, Malcolm M'N., F.R.A.S., 7 Westbourne ter., Fort Matilda, Greenock. 1853
595 *Wallace, Hugh, 30 Havelock street. 1879
*Wallace, Wm., M.A., M.B., C.M., Westfield house, Shawlands. 1888
Wallace, William, M.A., Allan Glen's School. 1890
Warren, John A., C.E., 115 Wellington street. 1887
Watson, Archibald, 5 Westbourne terrace. 1881
600 Watson, James, 24 Sandyford place. 1873
*Watson, John, 205 West George street. 1886
Watson, Joseph, 225 West George street. 1882
Watson, J. Robertson, M.A., Professor of Chemistry, Anderson's College Medical School. 1891
*Watson, Thomas Lennox, I.A., F.R.I.B.A., 108 W. Regent st. 1876
605 *Watson, Sir William Renny, 16 Woodlands terrace. 1870
Welsh, Thomas M., 3 Prince's gardens, Dowanhill. 1883
Wenley, James A., Bank of Scotland, Edinburgh. 1870
Westlands, Robert, 99 Mitchell street. 1869
Whyte, A. C., L.D.S., 42 Dundas street. 1892
610 Whyte, James, 62 Robertson street. 1893
White, John, Scotstoun Mills, Partick. 1875
Whitson, Alexander, jun., Ardlui, Bearsden. 1893
*Whitson, Jas., M.D., F.F.P.& S.G., 13 Somerset place. 1882
*Whitelaw, Thomas N., 87 Sydney street. 1892
615 Whytlaw, R. A., 1 Windsor quadrant, Kelvinside. 1885
Widmer, Justus, 21 Athole gardens. 1887
Williamson, John, 65 West Regent street. 1881
Wilson, Alex., Hydepark Foundry, 54 Finnieston street. 1874
Wilson, David, Carbeth, by Killearn. 1850
620 Wilson, William, Virginia buildings. 1881
Wilson, William, Castle Howard, Bulmer, York. 1889
Wilson, W. H., 21 Hope street. 1881
Wingate, Arthur, 10 Prince's gardens, Dowanhill. 1882
*Wingate, John B., 7 Crown terrace, Dowanhill. 1881

625 Wingate, P., 14 Westbourne ter. 1872
Wingate, Walter E., 4 Bowmont terrace. 1880
Wood, James, M.A., Glasgow Academy. 1885
Wood, James, 28 Royal Exchange sq. 1886
Wood, Wm. Copland, Turkey-red Works, Alexandria. 1883
630 Wood, W. E. H., 40 Candleriggs. 1891
Woodburn, J. Cowan, M.D., 197 Bath street. 1869

Yellowlees, D., M.D., LL.D., Physician-Superintendent, Gartnavel. 1881

Young, John, 2 Montague terrace, Kelvinside. 1885
Young, John, 64 Cochrane street. 1881
635 *Young, John, jun., M.A., B.Sc., 38 Bath street. 1887
Young, Robert Bruce, M.A., M.B., C.M., 8 Crown gardens. 1892
Young, Thomas, 58 Renfield straet. 1892
*Young, Thos. Graham, Westfield, West Calder. 1880
Younger, George, 166 Ingram street. 1847

640 Zinkeisen, Victor, 225 George street. 1881

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